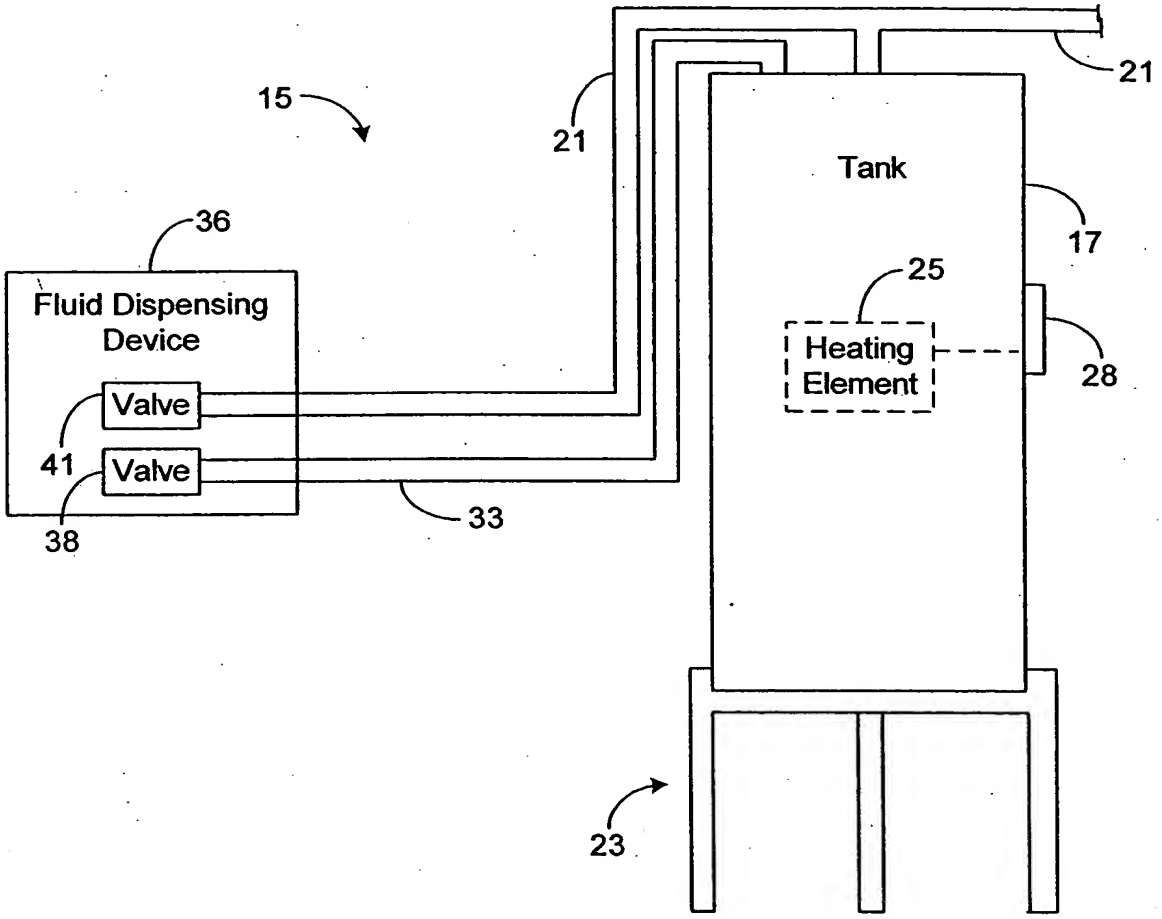

FIG. 1
(Prior Art)

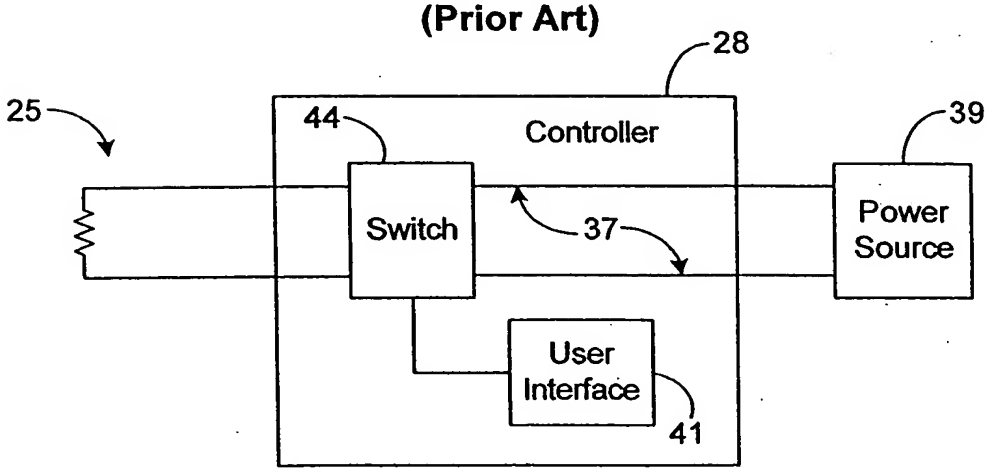

FIG. 2
(Prior Art)

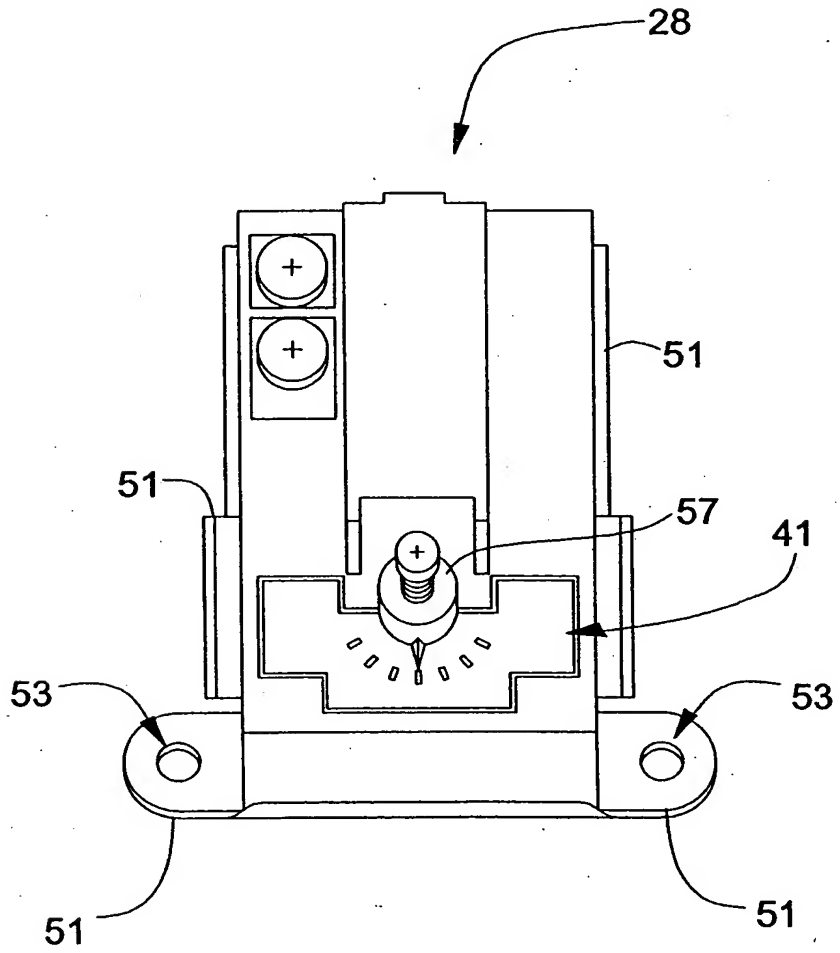

FIG. 3
(Prior Art)

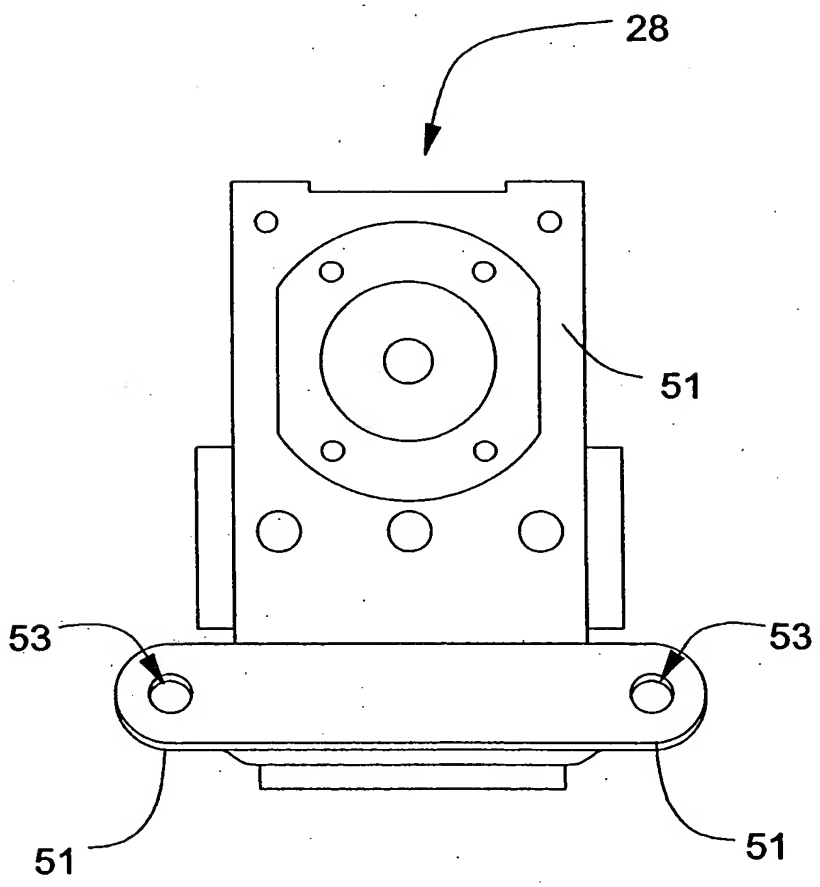

FIG. 4
(Prior Art)

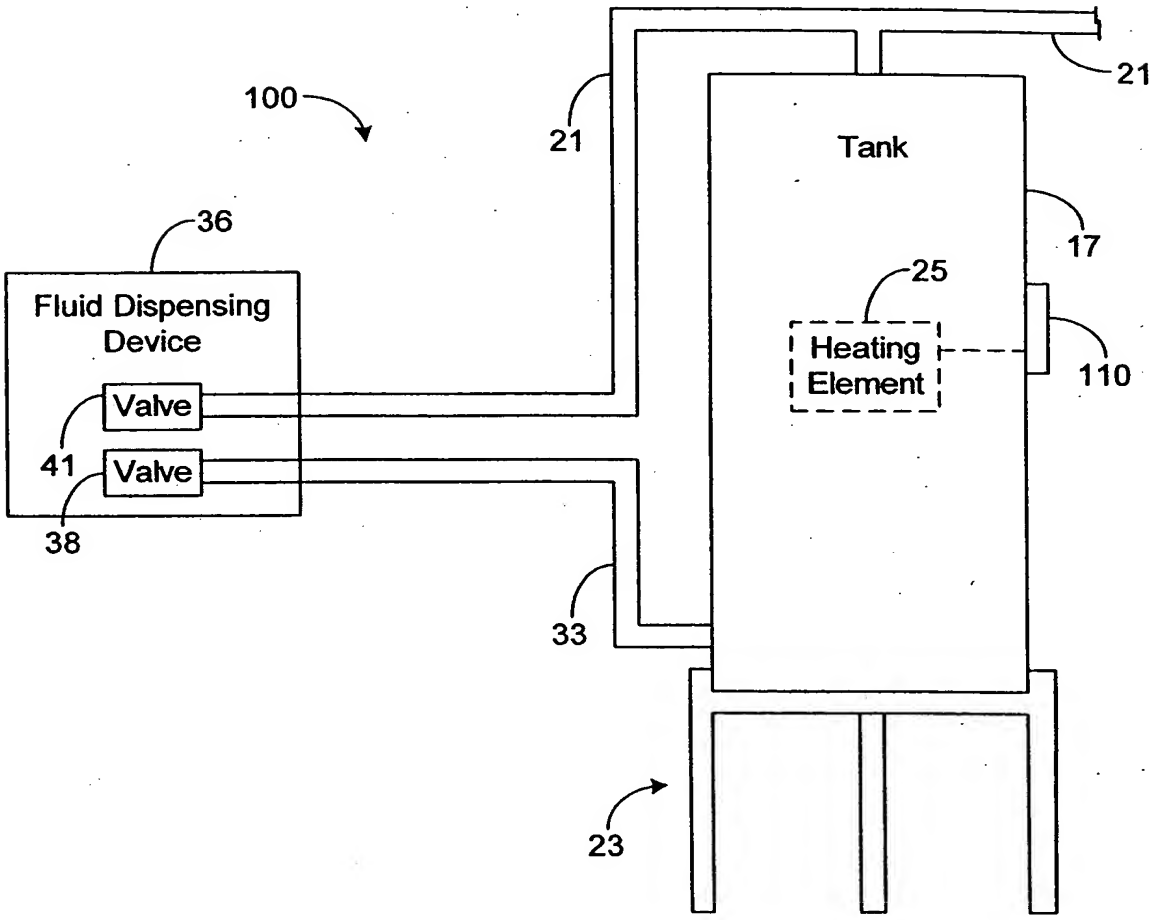
100
21
21
Tank
17
36
Fluid Dispensing Device
25
Heating Element
110
Valve
41
Valve
38
33
23

FIG. 5

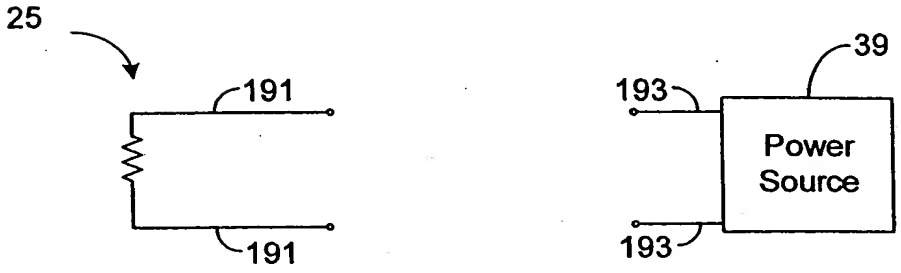
25
191
191
39
193
Power Source
193

FIG. 6A

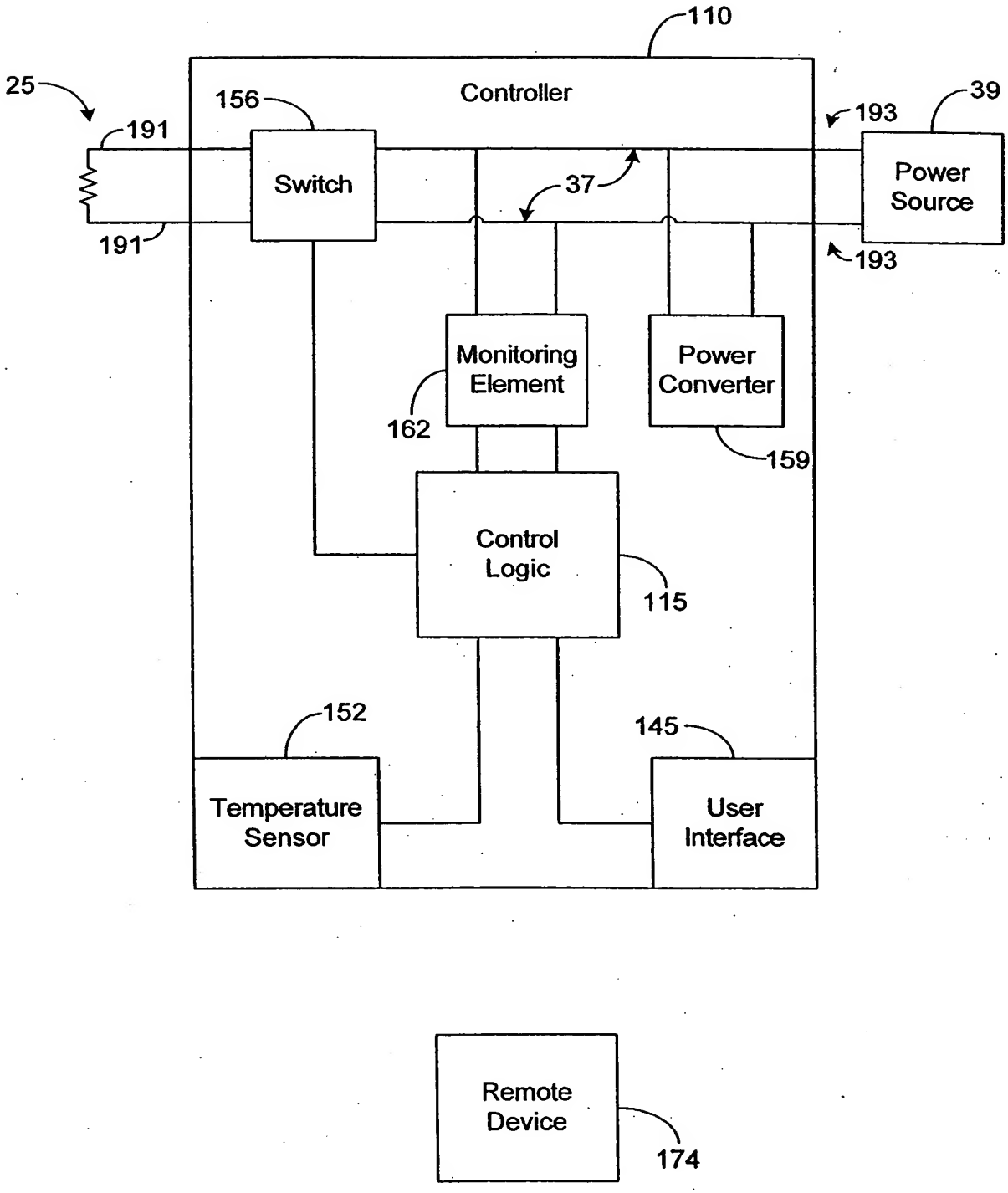
110
Controller
25
156
191
Switch
37
39
193
Power Source
191
193
Monitoring Element
162
Power Converter
159
Control Logic
115
152
145
Temperature Sensor
User Interface
Remote Device
174

FIG. 6B

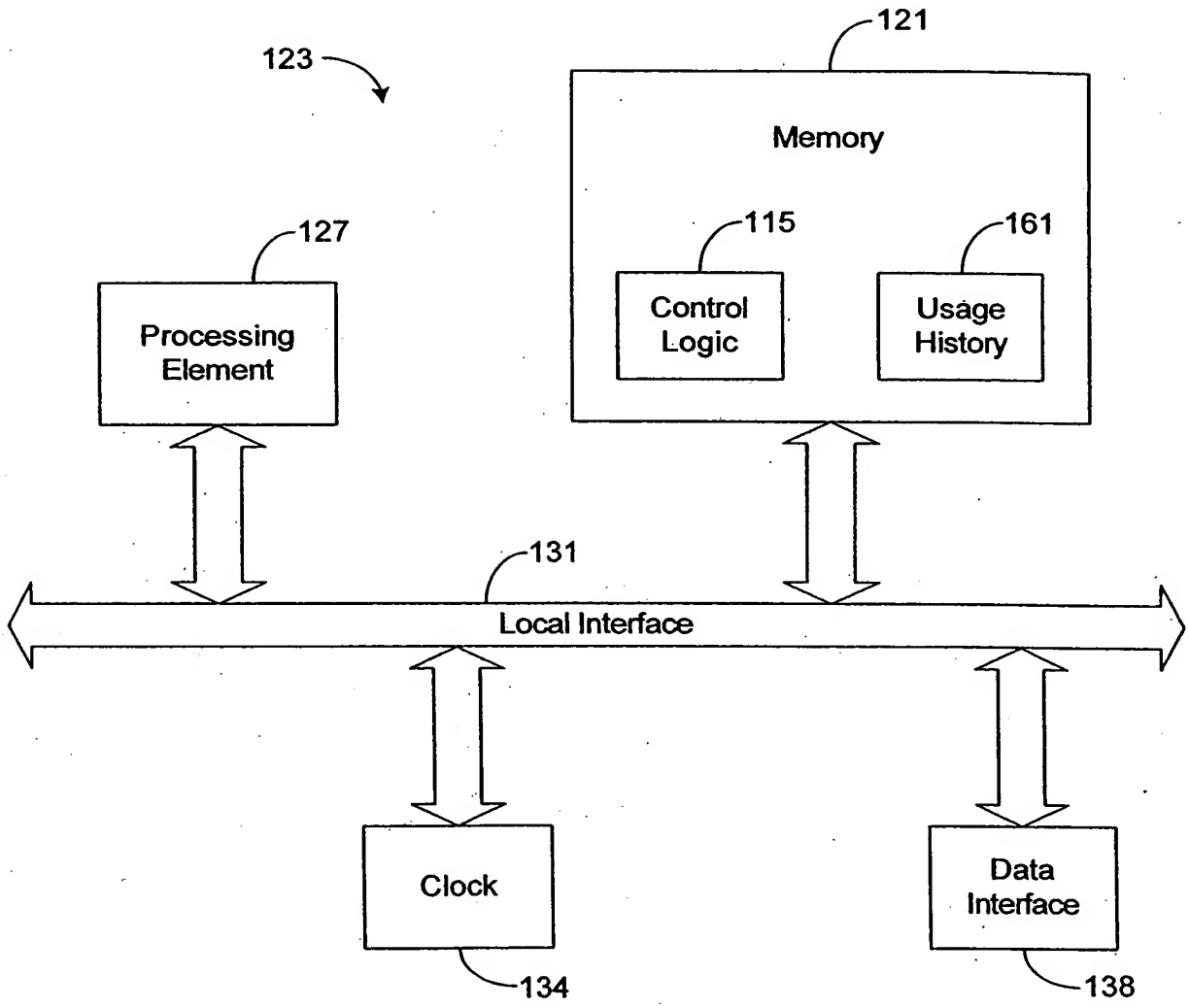
123
121
Memory
115
Control Logic
161
Usage History
127
Processing Element
131
Local Interface
Clock
134
Data Interface
138

FIG. 7

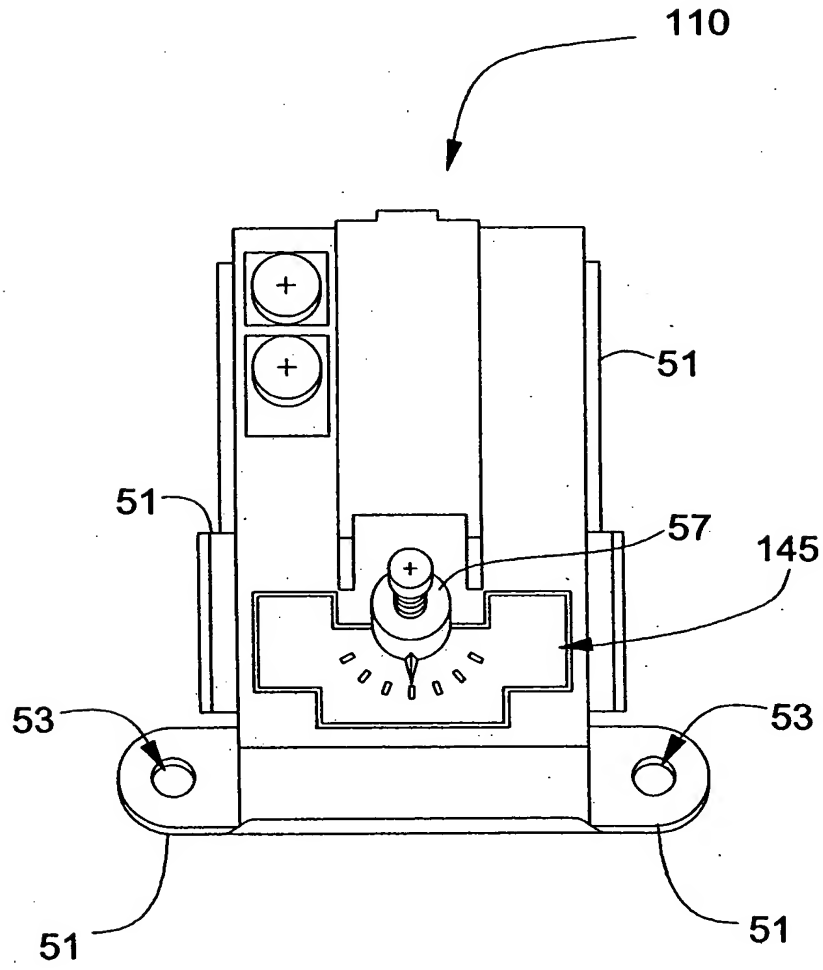

FIG. 8

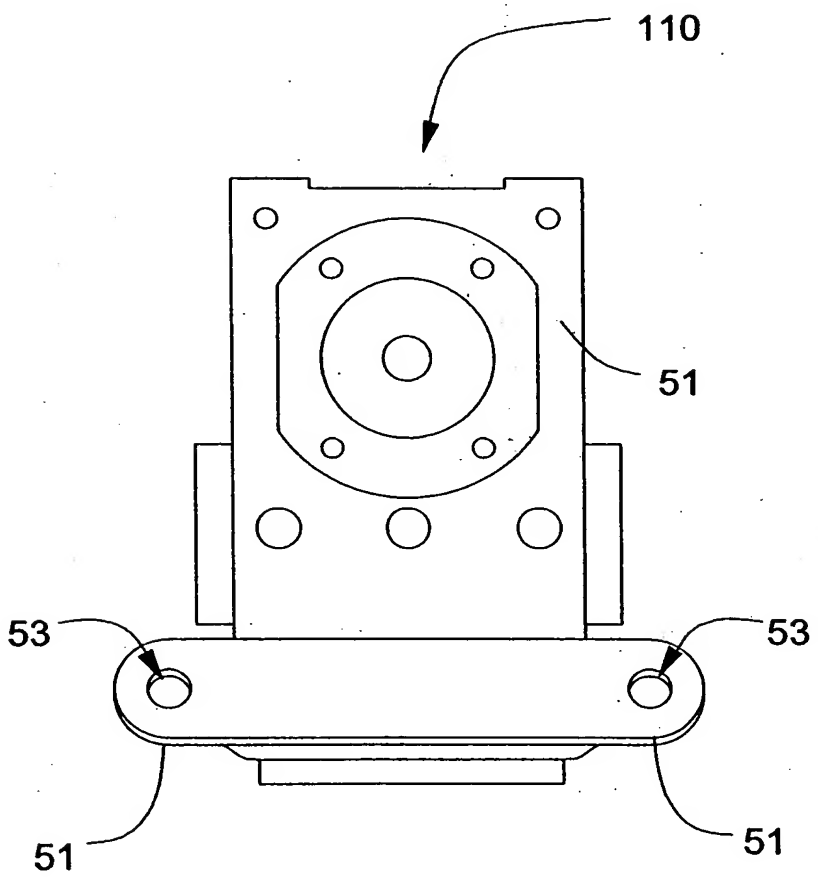

FIG. 9

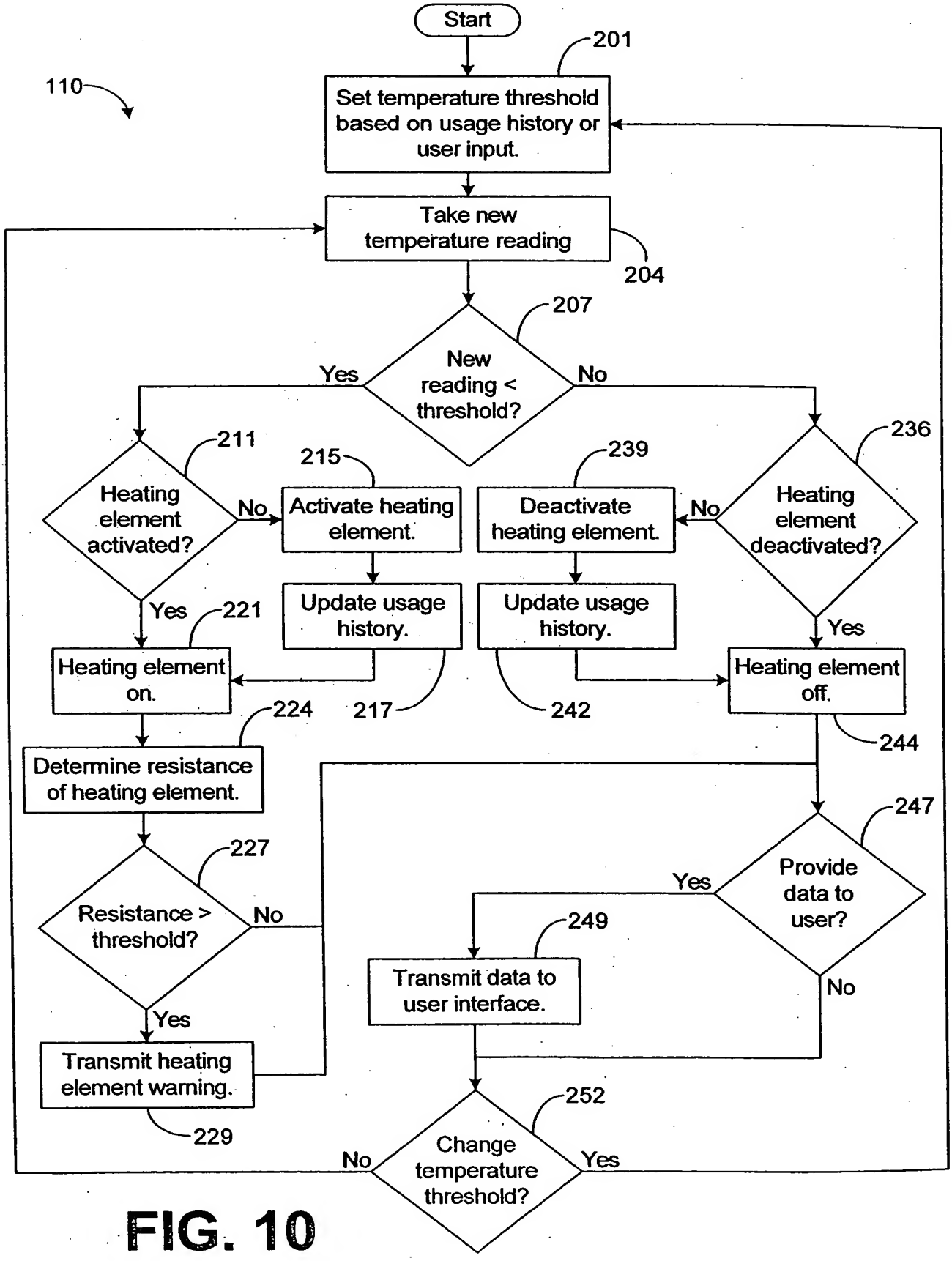
Start
201
110
Set temperature threshold based on usage history or user input.
Take new temperature reading
204
207
New reading < threshold?
Yes
No
211
Heating element activated?
No
215
Activate heating element.
Update usage history.
217
Yes
221
Heating element on.
224
Determine resistance of heating element.
227
Resistance > threshold?
No
Yes
Transmit heating element warning.
229
239
Deactivate heating element.
Update usage history.
242
236
Heating element deactivated?
No
Yes
Heating element off.
244
247
Provide data to user?
Yes
No
249
Transmit data to user interface.
252
Change temperature threshold?
No
Yes

FIG. 10

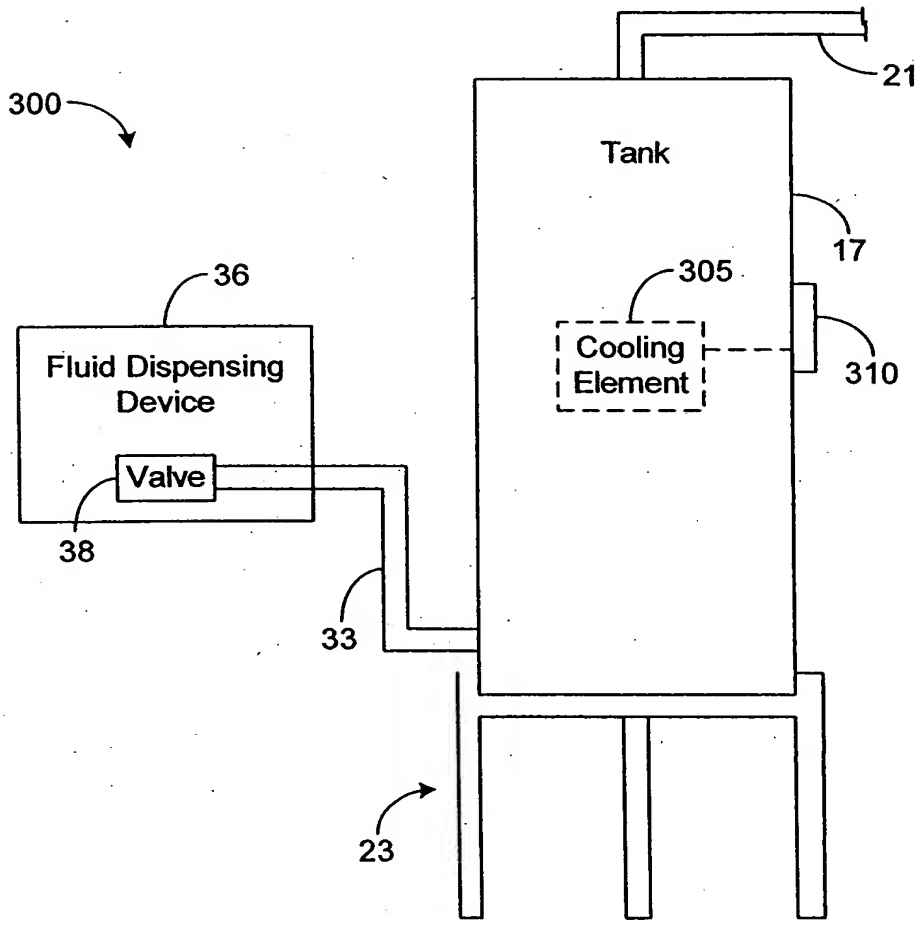
300
21
Tank
17
36
305
Fluid Dispensing Device
Cooling Element
310
Valve
38
33
23

FIG. 11

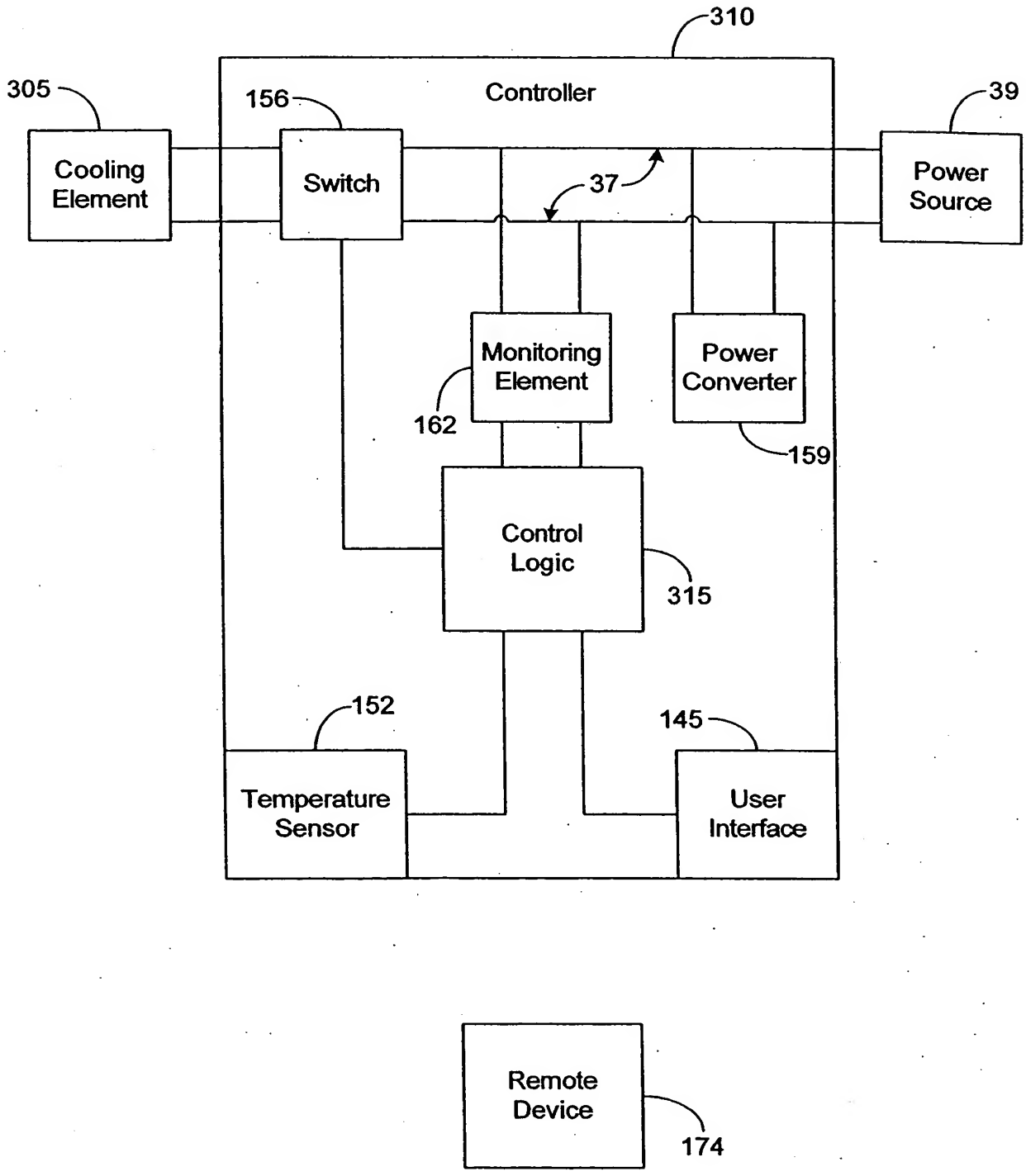
310
Controller
305
156
39
Cooling Element
Switch
37
Power Source
Monitoring Element
Power Converter
162
159
Control Logic
315
152
145
Temperature Sensor
User Interface
Remote Device
174

FIG. 12

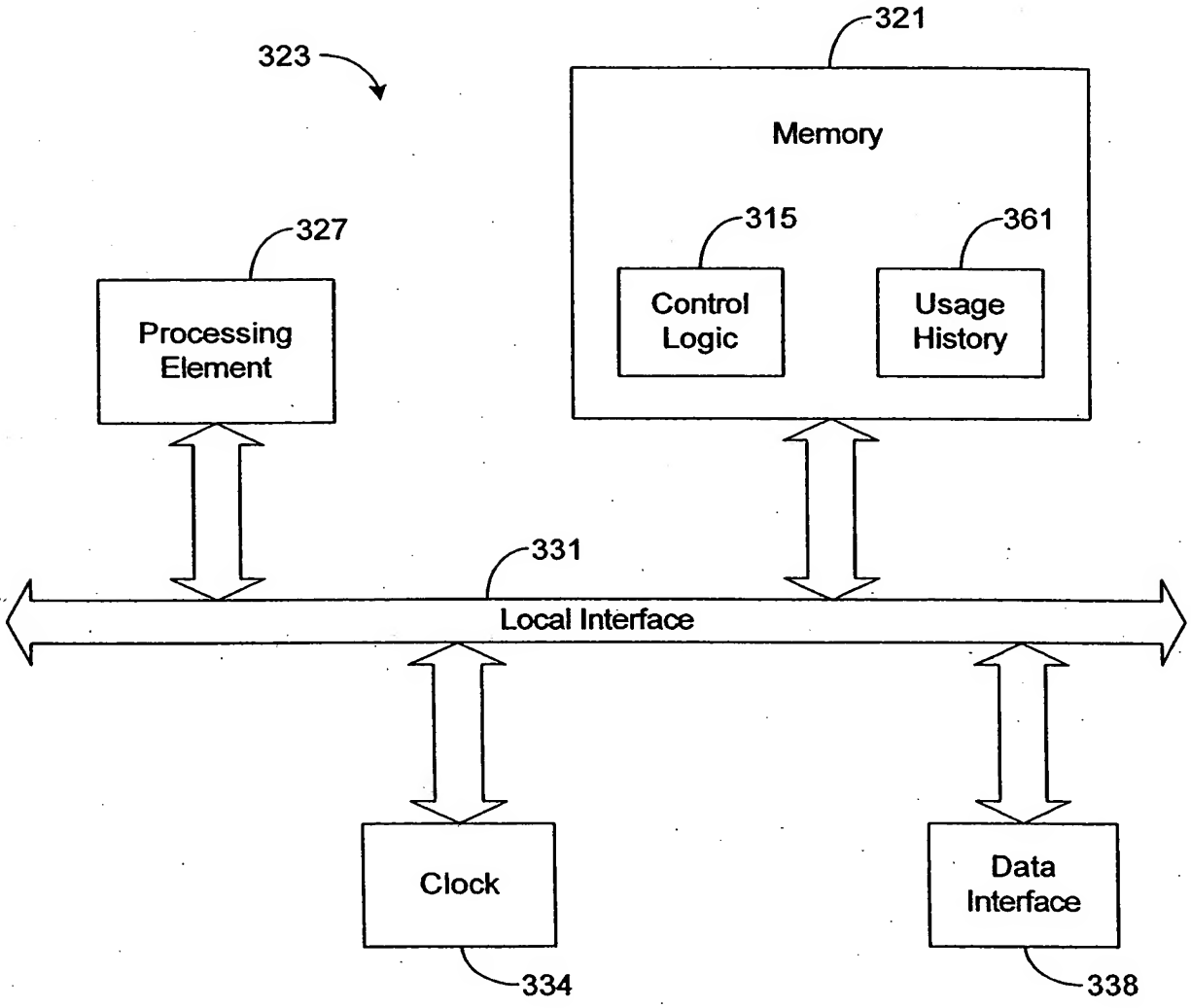
323
321
Memory
315
Control Logic
361
Usage History
327
Processing Element
331
Local Interface
Clock
334
Data Interface
338

FIG. 13

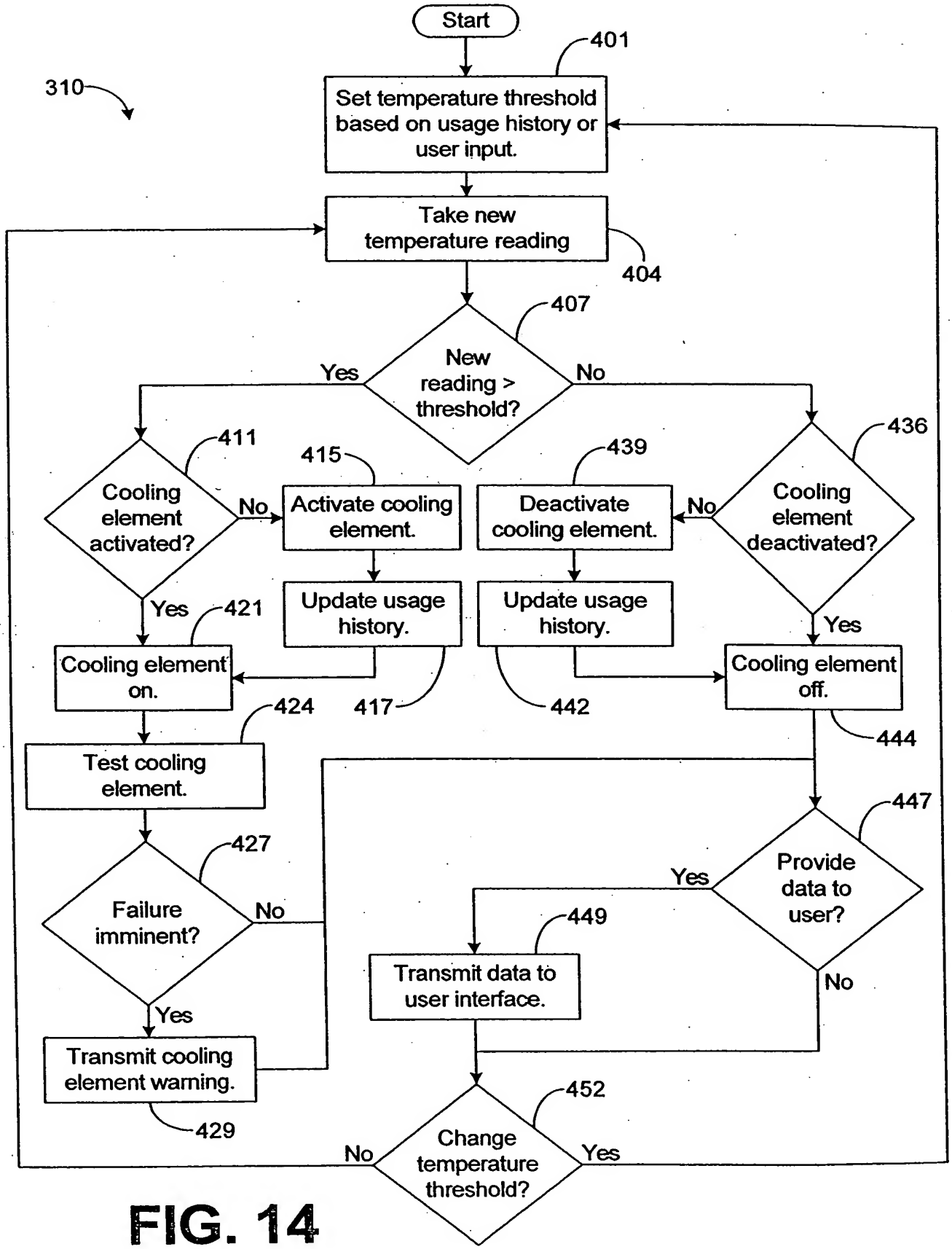
Start
401
310
Set temperature threshold based on usage history or user input.
Take new temperature reading
404
407
New reading > threshold?
Yes
No
411
Cooling element activated?
No
415
Activate cooling element.
439
Deactivate cooling element.
No
436
Cooling element deactivated?
Yes
421
Cooling element on.
Update usage history.
Update usage history.
Yes
Cooling element off.
417
442
424
Test cooling element.
444
447
427
Failure imminent?
No
Yes
Provide data to user?
Yes
449
Transmit data to user interface.
No
Transmit cooling element warning.
429
452
Change temperature threshold?
No
Yes

FIG. 14

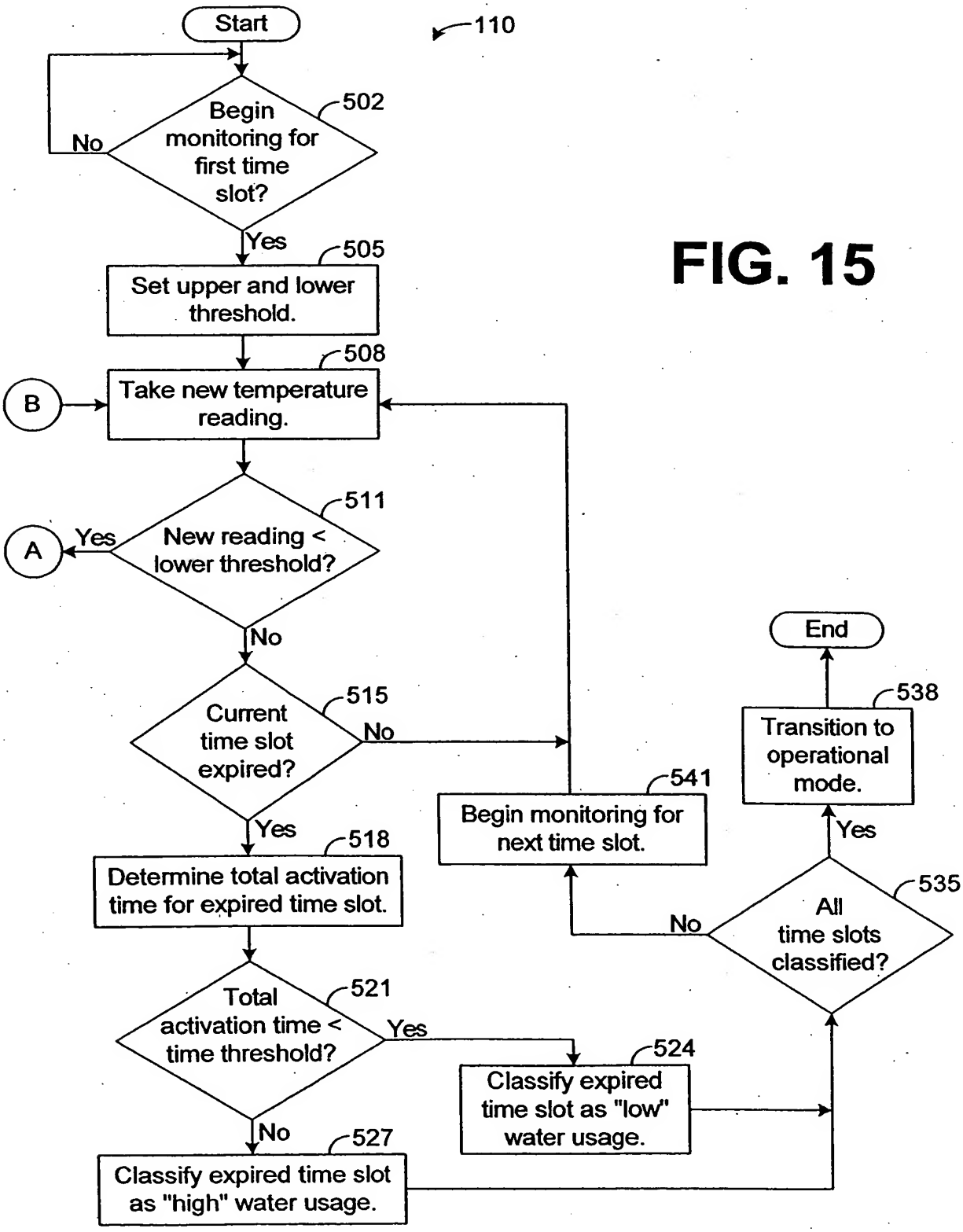
Start
110
Begin monitoring for first time slot?
502
No
Yes
Set upper and lower threshold.
505
Take new temperature reading.
508
B
New reading < lower threshold?
511
A
Yes
No
Current time slot expired?
515
No
Yes
Determine total activation time for expired time slot.
518
Total activation time < time threshold?
521
Yes
No
Classify expired time slot as "high" water usage.
527
Classify expired time slot as "low" water usage.
524
Begin monitoring for next time slot.
541
All time slots classified?
535
No
Yes
Transition to operational mode.
538
End

FIG. 15

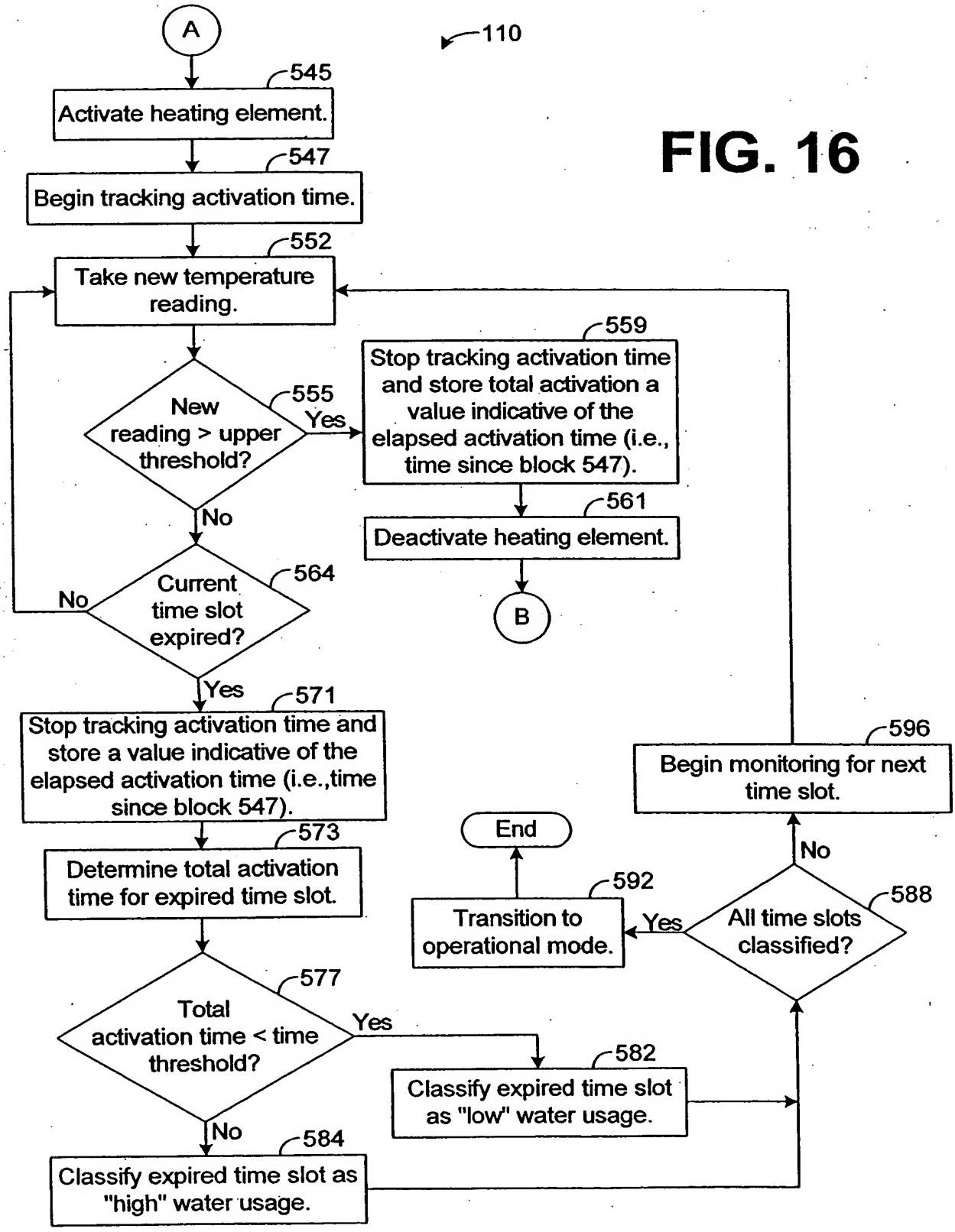
A
110
545
Activate heating element.
547
Begin tracking activation time.
552
Take new temperature reading.
559
Stop tracking activation time and store total activation a value indicative of the elapsed activation time (i.e., time since block 547).
555
New reading > upper threshold?
Yes
No
561
Deactivate heating element.
B
564
Current time slot expired?
No
Yes
571
Stop tracking activation time and store a value indicative of the elapsed activation time (i.e.,time since block 547).
573
Determine total activation time for expired time slot.
577
Total activation time < time threshold?
Yes
No
582
Classify expired time slot as "low" water usage.
584
Classify expired time slot as "high" water usage.
596
Begin monitoring for next time slot.
End
592
Transition to operational mode.
588
All time slots classified?
Yes
No

FIG. 16

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1:00	low	low	low	low	low	low	low
2:00	low	low	low	low	low	low	low
3:00	low	low	low	low	low	low	low
4:00	low	low	low	low	low	low	low
5:00	low	low	high	low	high	low	low
6:00	high	high	low	high	high	low	high
7:00	high	low	low	low	low	low	high
8:00	low	high	high	high	low	high	low
9:00	low	low	low	low	low	high	low
10:00	low	low	low	low	low	low	low
11:00	low	low	low	low	high	low	low
12:00	high	low	low	low	low	high	low
13:00	low	high	low	high	low	high	low
14:00	low	low	low	low	low	low	low
15:00	low	low	low	low	low	low	low
16:00	low	low	low	low	high	high	high
17:00	high	low	low	low	high	high	high
18:00	high	high	low	high	high	high	high
19:00	high	high	low	high	low	high	low
20:00	low	high	low	high	low	low	low
21:00	low	low	low	low	low	low	low
22:00	low	low	low	low	low	low	low
23:00	low	low	low	low	low	low	low

599

FIG. 17

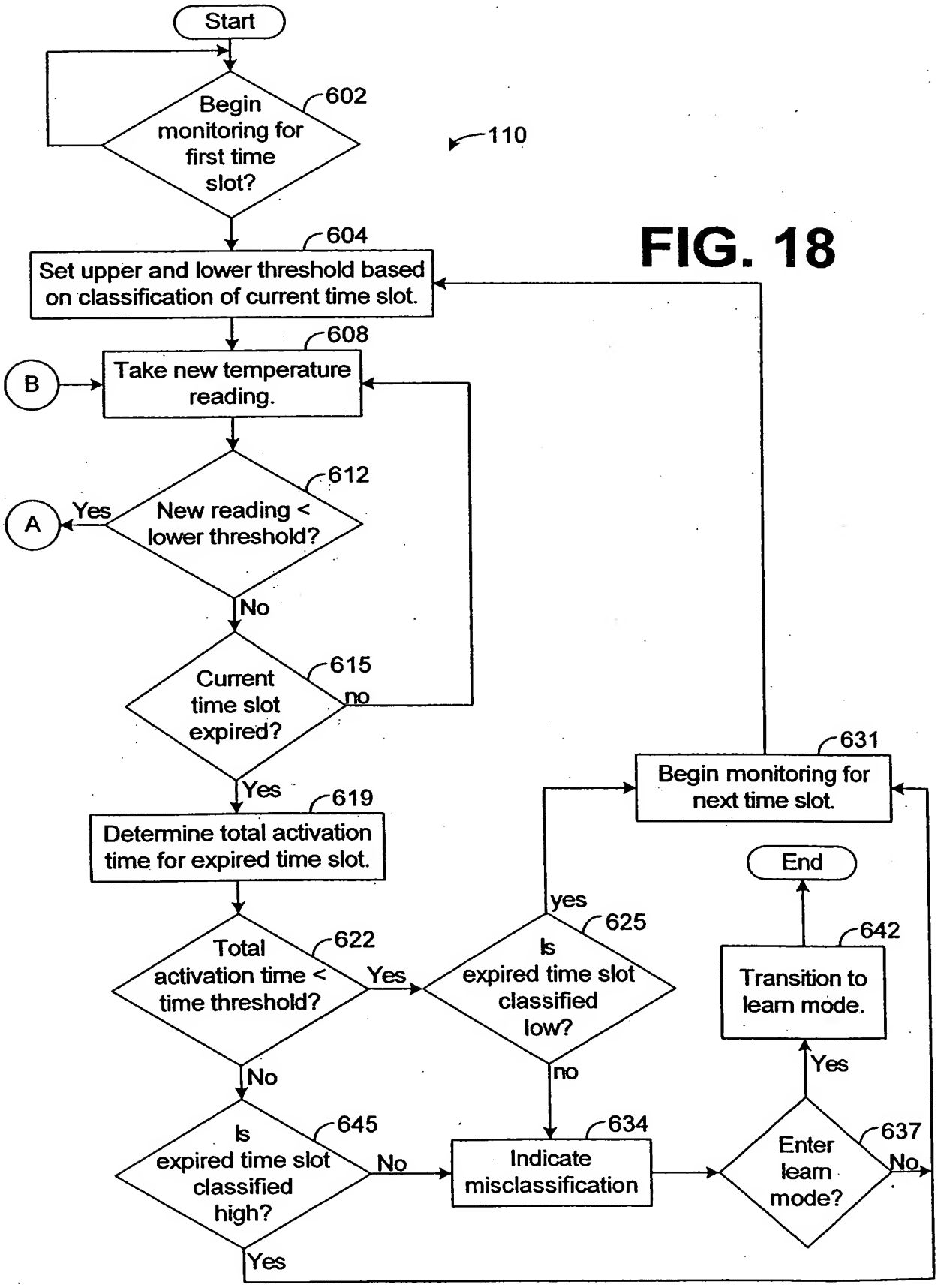
Start
Begin monitoring for first time slot?
602
110
Set upper and lower threshold based on classification of current time slot.
604
Take new temperature reading.
608
B
New reading < lower threshold?
612
Yes
A
No
Current time slot expired?
615
no
Yes
Determine total activation time for expired time slot.
619
Total activation time < time threshold?
622
Yes
No
Is expired time slot classified high?
645
No
Yes
Is expired time slot classified low?
625
yes
no
Indicate misclassification
634
Begin monitoring for next time slot.
631
Enter learn mode?
637
No
Yes
Transition to learn mode.
642
End

FIG. 18

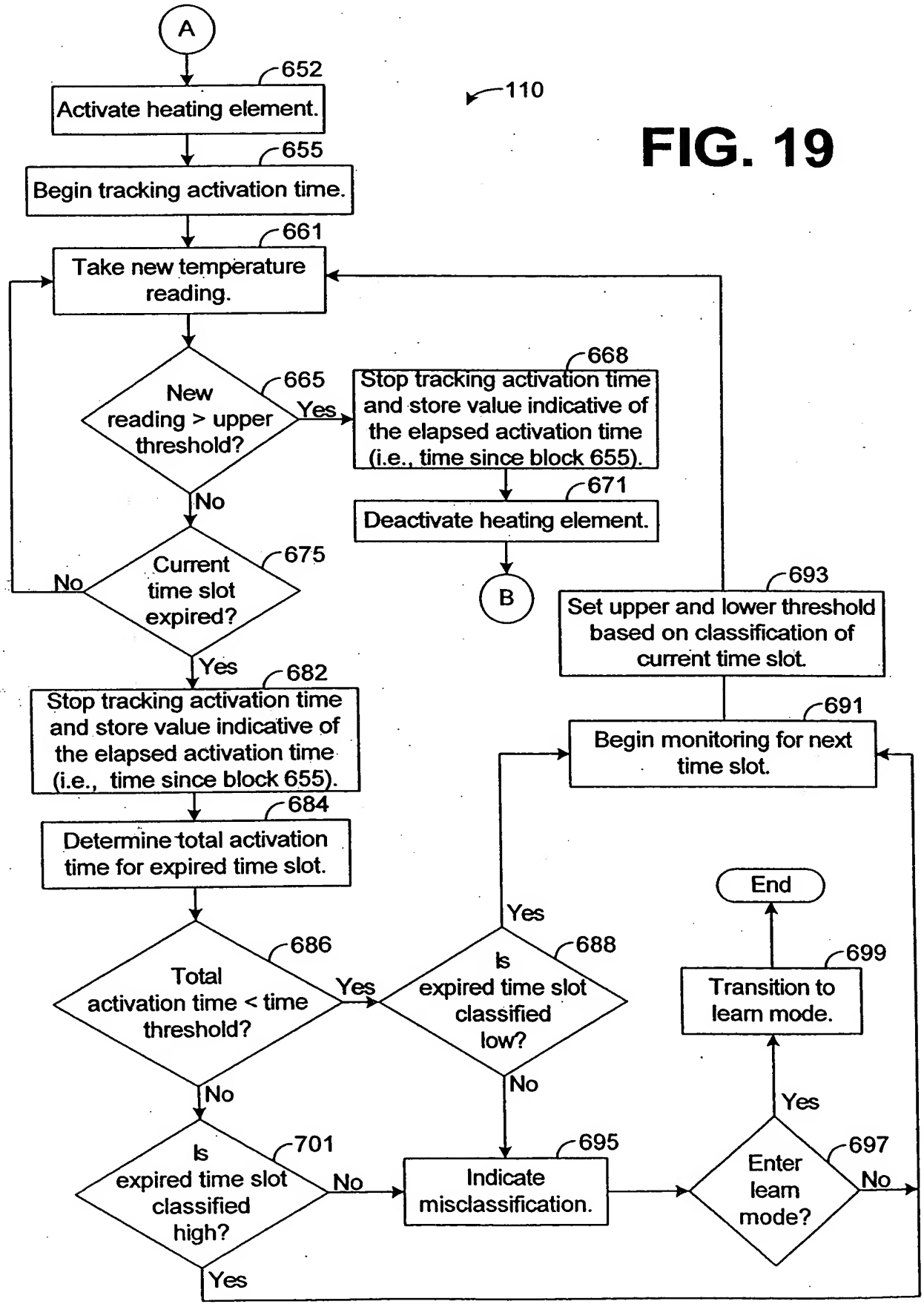
A
652
Activate heating element.
655
Begin tracking activation time.
661
Take new temperature reading.
665
New reading > upper threshold?
Yes
668
Stop tracking activation time and store value indicative of the elapsed activation time (i.e., time since block 655).
671
Deactivate heating element.
B
No
675
Current time slot expired?
No
Yes
682
Stop tracking activation time and store value indicative of the elapsed activation time (i.e., time since block 655).
684
Determine total activation time for expired time slot.
686
Total activation time < time threshold?
Yes
688
Is expired time slot classified low?
Yes
No
No
701
Is expired time slot classified high?
No
695
Indicate misclassification.
Yes
693
Set upper and lower threshold based on classification of current time slot.
691
Begin monitoring for next time slot.
End
699
Transition to learn mode.
Yes
697
Enter learn mode?
No
110

FIG. 19

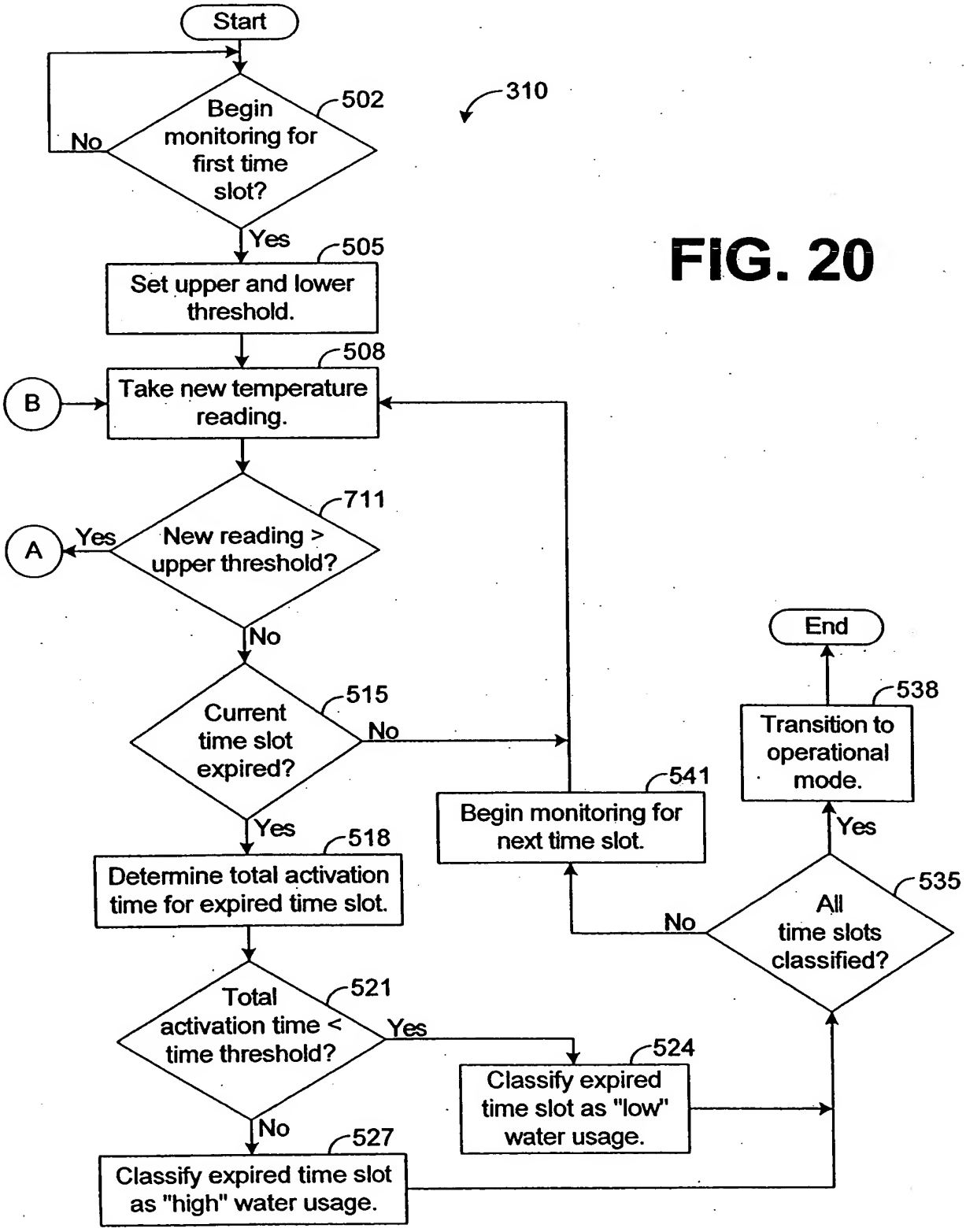
Start
Begin monitoring for first time slot?
502
310
No
Yes
Set upper and lower threshold.
505
Take new temperature reading.
508
B
New reading > upper threshold?
711
A
Yes
No
Current time slot expired?
515
No
Yes
Determine total activation time for expired time slot.
518
Total activation time < time threshold?
521
Yes
No
Classify expired time slot as "high" water usage.
527
Classify expired time slot as "low" water usage.
524
Begin monitoring for next time slot.
541
All time slots classified?
535
No
Yes
Transition to operational mode.
538
End

FIG. 20

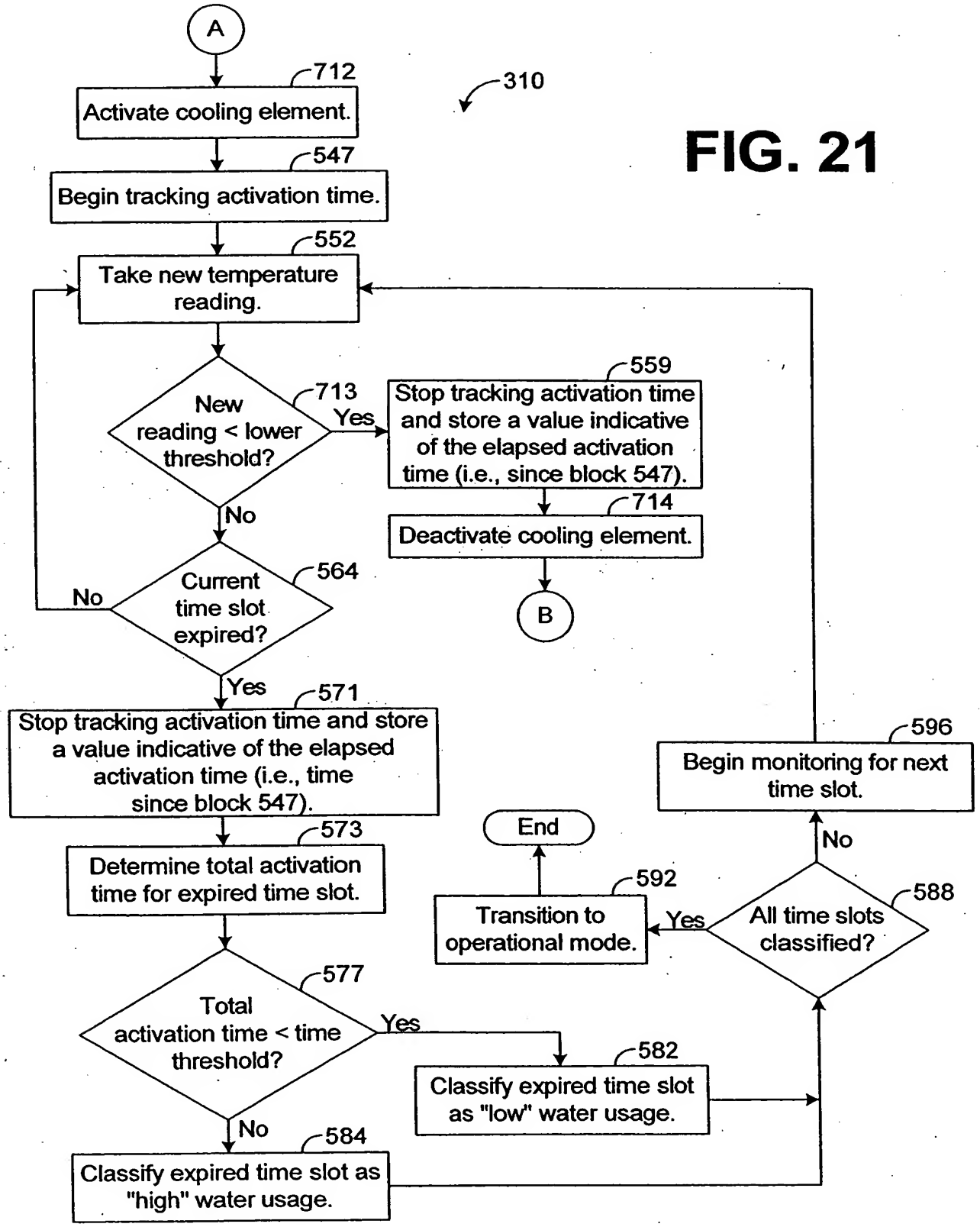
A
712
Activate cooling element.
310
547
Begin tracking activation time.
552
Take new temperature reading.
713
New reading < lower threshold?
Yes
559
Stop tracking activation time and store a value indicative of the elapsed activation time (i.e., since block 547).
No
714
Deactivate cooling element.
B
564
Current time slot expired?
No
Yes
571
Stop tracking activation time and store a value indicative of the elapsed activation time (i.e., time since block 547).
596
Begin monitoring for next time slot.
End
573
Determine total activation time for expired time slot.
592
Transition to operational mode.
Yes
588
All time slots classified?
No
577
Total activation time < time threshold?
Yes
582
Classify expired time slot as "low" water usage.
No
584
Classify expired time slot as "high" water usage.

FIG. 21

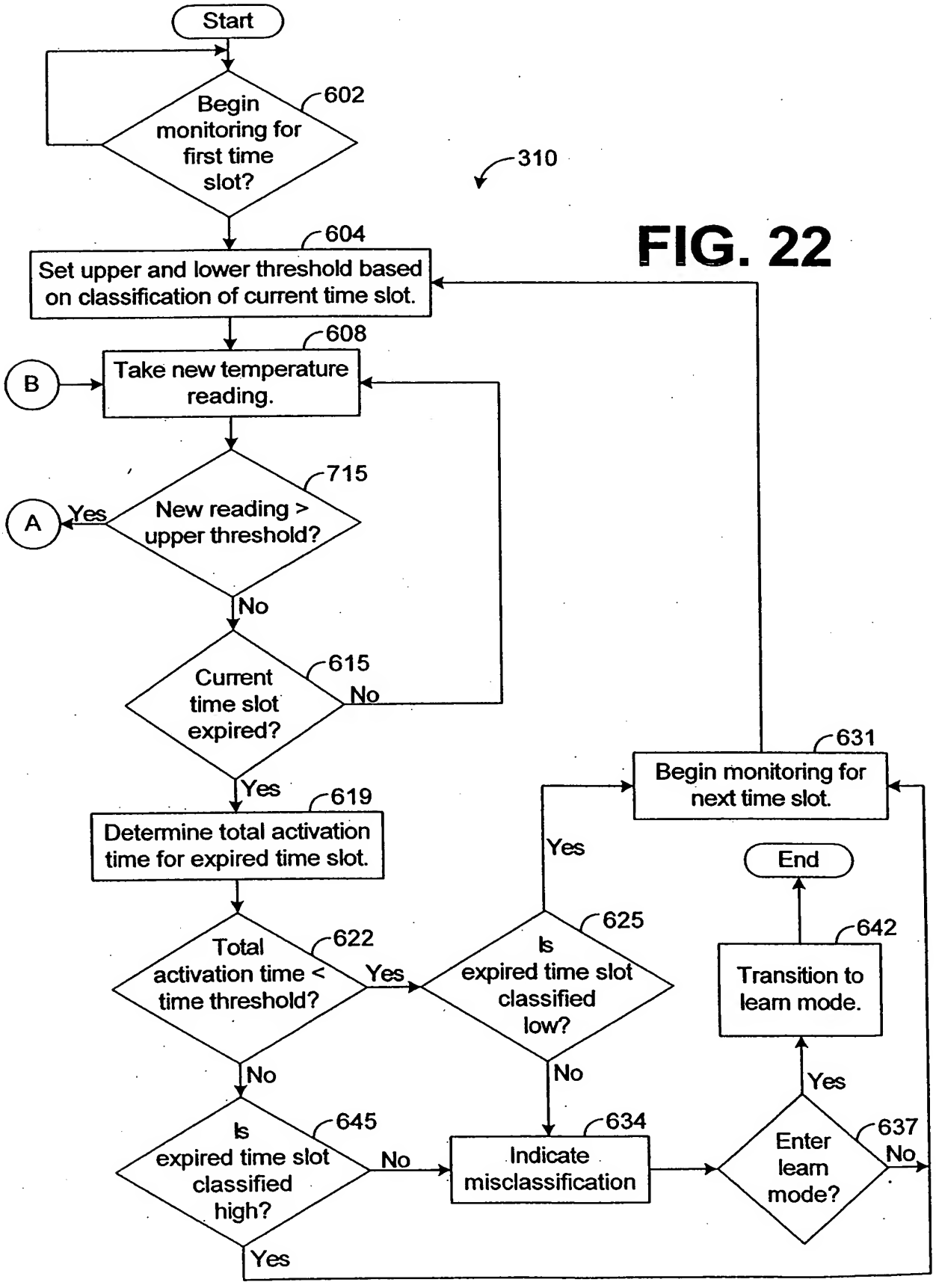
Start
Begin monitoring for first time slot?
602
310
Set upper and lower threshold based on classification of current time slot.
604
Take new temperature reading.
608
B
New reading > upper threshold?
715
Yes
A
No
Current time slot expired?
615
No
Yes
Determine total activation time for expired time slot.
619
Total activation time < time threshold?
622
Yes
Is expired time slot classified low?
625
Yes
No
Is expired time slot classified high?
645
No
Indicate misclassification
634
Enter learn mode?
637
No
Yes
Transition to learn mode.
642
End
Begin monitoring for next time slot.
631
Yes

FIG. 22

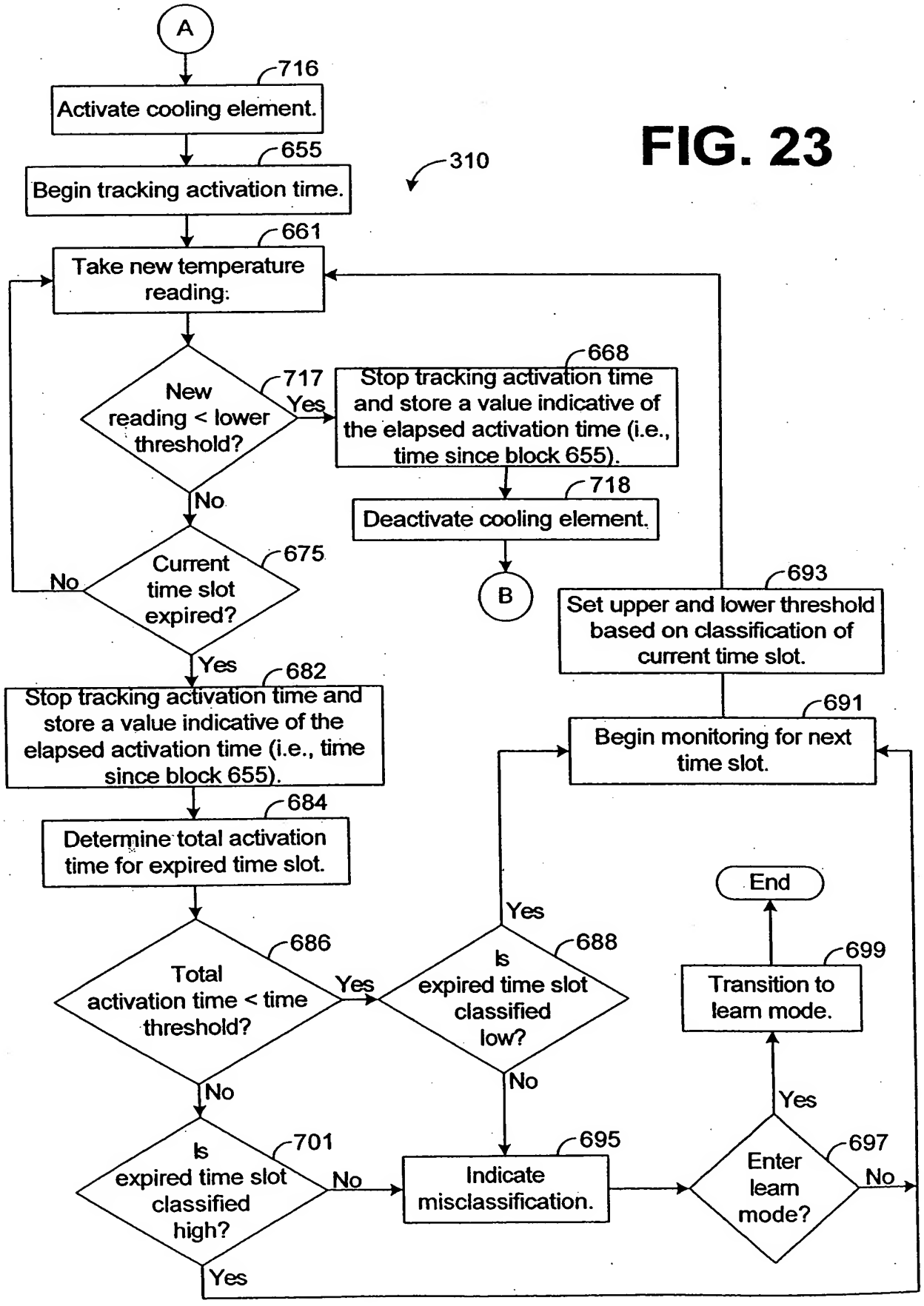
A
716
Activate cooling element.
655
Begin tracking activation time.
310
661
Take new temperature reading.
New reading < lower threshold?
717
Yes
668
Stop tracking activation time and store a value indicative of the elapsed activation time (i.e., time since block 655).
718
Deactivate cooling element.
B
No
Current time slot expired?
675
No
Yes
682
Stop tracking activation time and store a value indicative of the elapsed activation time (i.e., time since block 655).
684
Determine total activation time for expired time slot.
686
Total activation time < time threshold?
Yes
No
688
Is expired time slot classified low?
Yes
No
701
Is expired time slot classified high?
No
Yes
695
Indicate misclassification.
693
Set upper and lower threshold based on classification of current time slot.
691
Begin monitoring for next time slot.
End
699
Transition to learn mode.
Yes
697
Enter learn mode?
No

FIG. 23

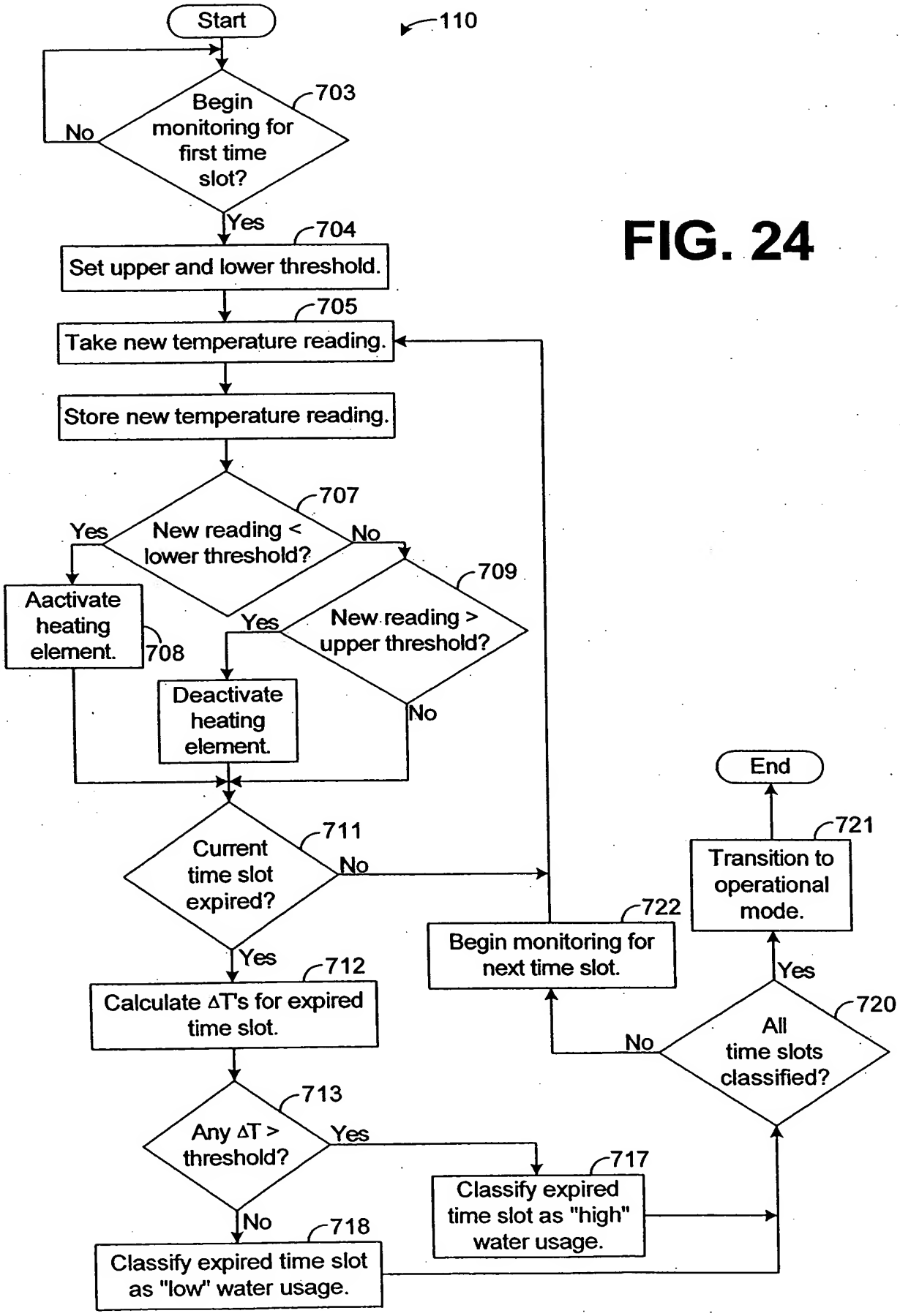
Start
110
Begin monitoring for first time slot?
703
No
Yes
Set upper and lower threshold.
704
Take new temperature reading.
705
Store new temperature reading.
New reading < lower threshold?
707
Yes
No
Aactivate heating element.
708
New reading > upper threshold?
709
Yes
Deactivate heating element.
No
Current time slot expired?
711
No
Yes
Calculate ΔT's for expired time slot.
712
Any ΔT > threshold?
713
Yes
No
Classify expired time slot as "low" water usage.
718
Classify expired time slot as "high" water usage.
717
Begin monitoring for next time slot.
722
All time slots classified?
720
No
Yes
Transition to operational mode.
721
End

FIG. 24

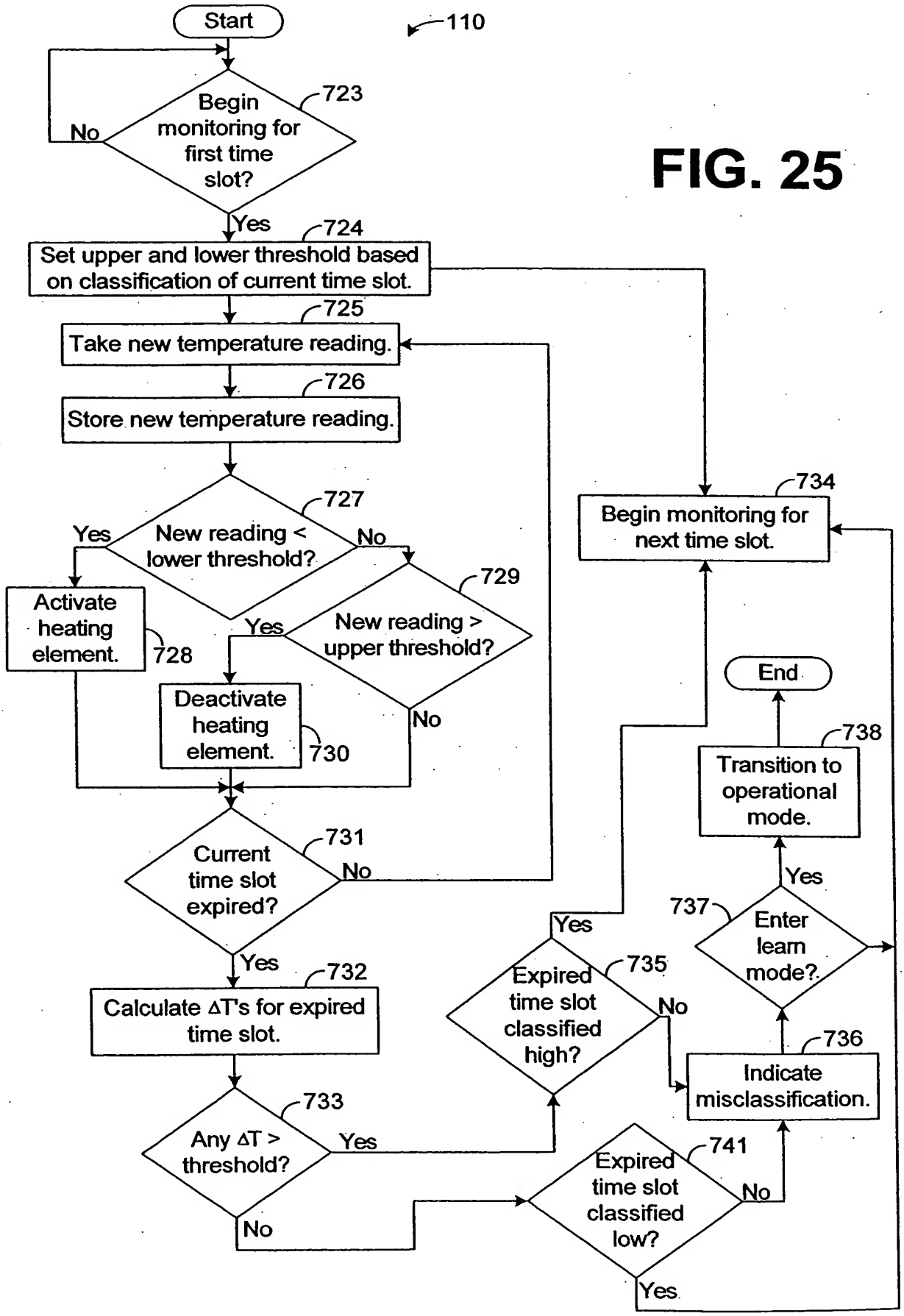
Start
110
Begin monitoring for first time slot?
723
No
Yes
Set upper and lower threshold based on classification of current time slot.
724
Take new temperature reading.
725
Store new temperature reading.
726
New reading < lower threshold?
727
Yes
No
Activate heating element.
728
New reading > upper threshold?
729
Yes
No
Deactivate heating element.
730
Current time slot expired?
731
No
Yes
Calculate ΔT's for expired time slot.
732
Any ΔT > threshold?
733
Yes
No
Begin monitoring for next time slot.
734
Expired time slot classified high?
735
Yes
No
Enter learn mode?
737
Yes
Transition to operational mode.
738
End
Indicate misclassification.
736
Expired time slot classified low?
741
No
Yes

FIG. 25

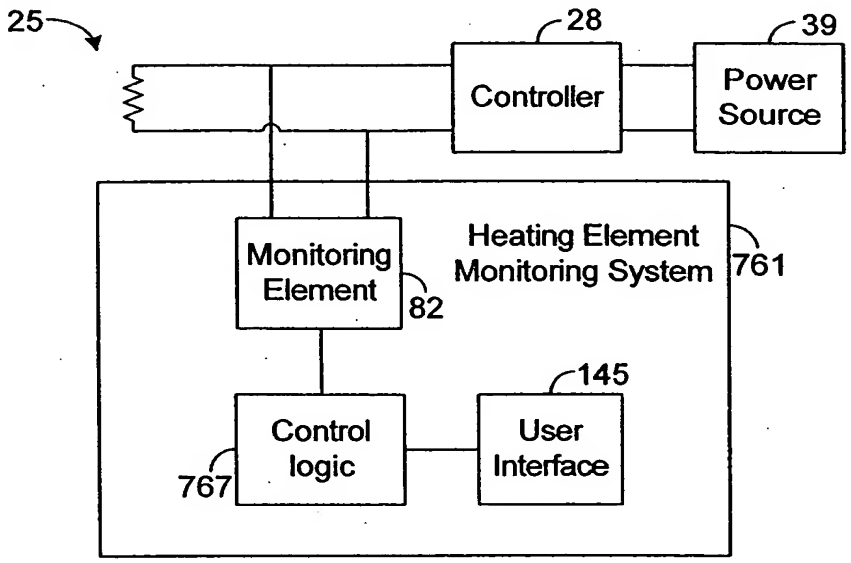
25
28
Controller
39
Power Source
Monitoring Element
82
Heating Element Monitoring System
761
145
Control logic
767
User Interface

FIG. 26

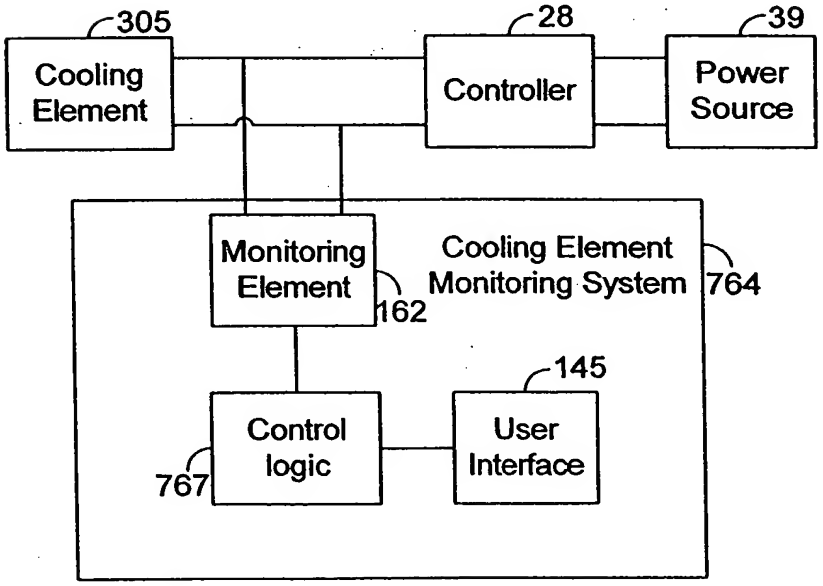
305
Cooling Element
28
Controller
39
Power Source
Monitoring Element
162
Cooling Element Monitoring System
764
145
Control logic
767
User Interface

FIG. 27

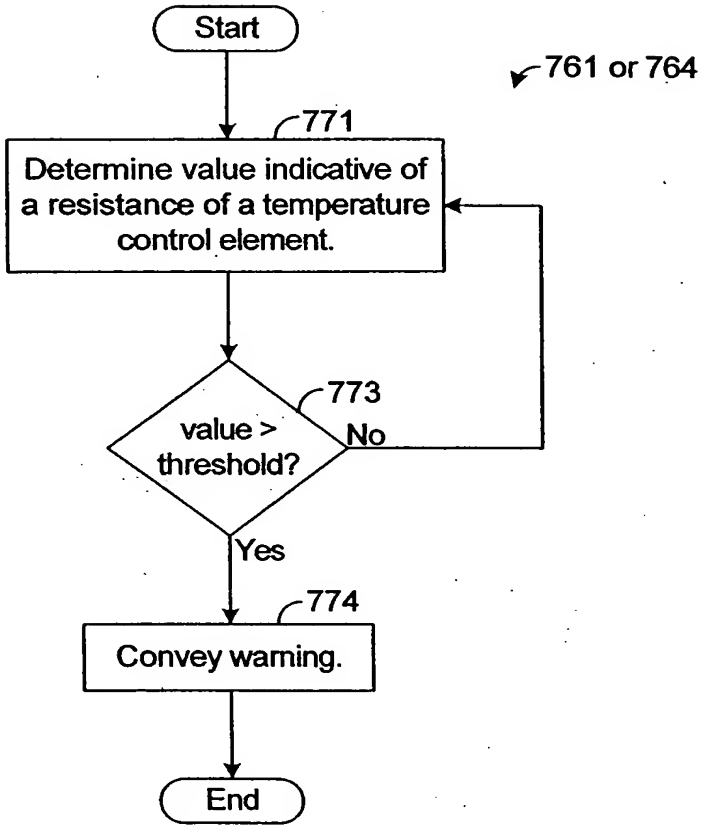
Start
761 or 764
771
Determine value indicative of a resistance of a temperature control element.
773
value > threshold?
No
Yes
774
Convey warning.
End

FIG. 28

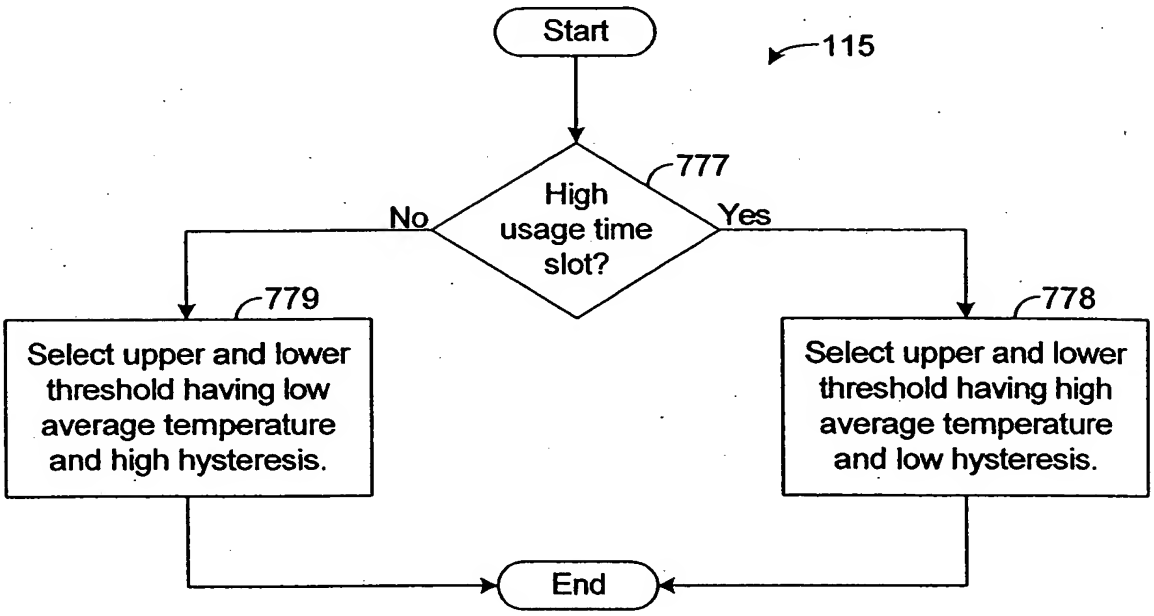
Start
115
777
High usage time slot?
No
Yes
779
Select upper and lower threshold having low average temperature and high hysteresis.
778
Select upper and lower threshold having high average temperature and low hysteresis.
End

FIG. 29

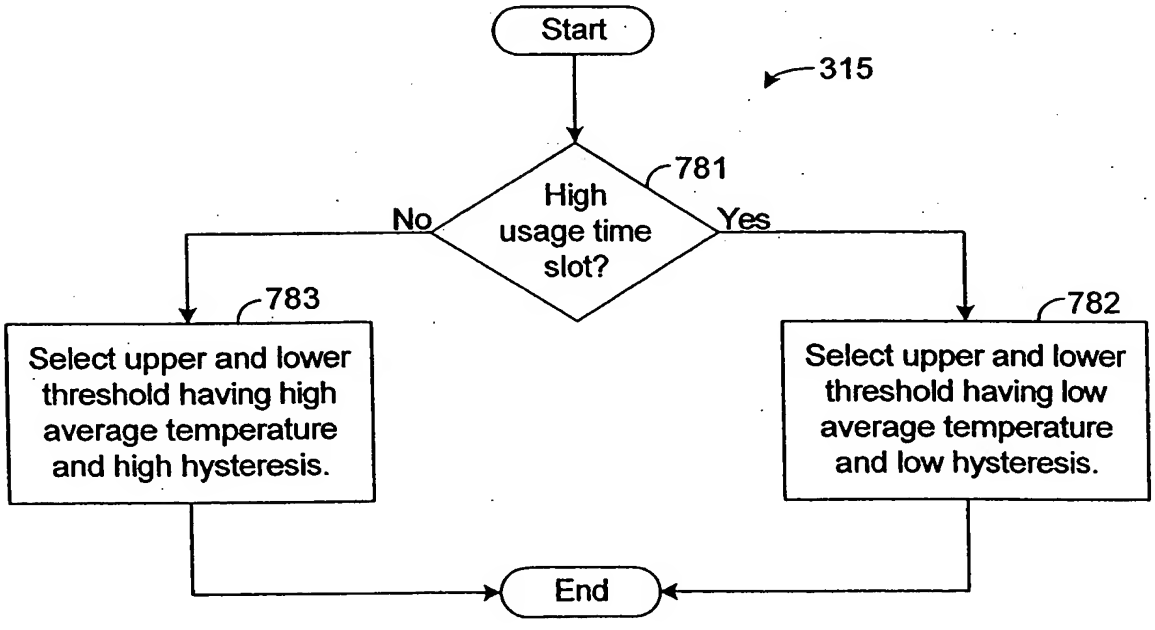
Start
315
781
High usage time slot?
No
Yes
783
Select upper and lower threshold having high average temperature and high hysteresis.
782
Select upper and lower threshold having low average temperature and low hysteresis.
End

FIG. 30

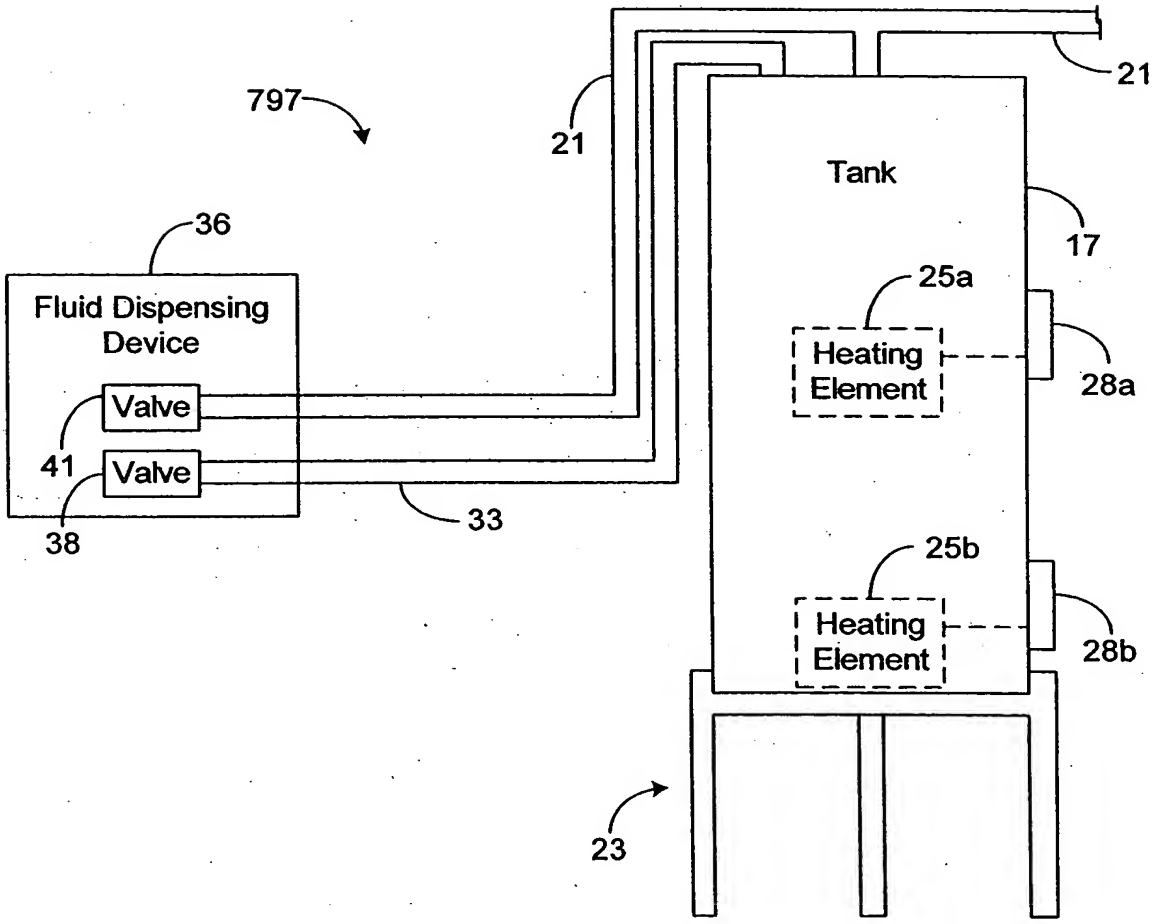

FIG. 31
(Prior Art)

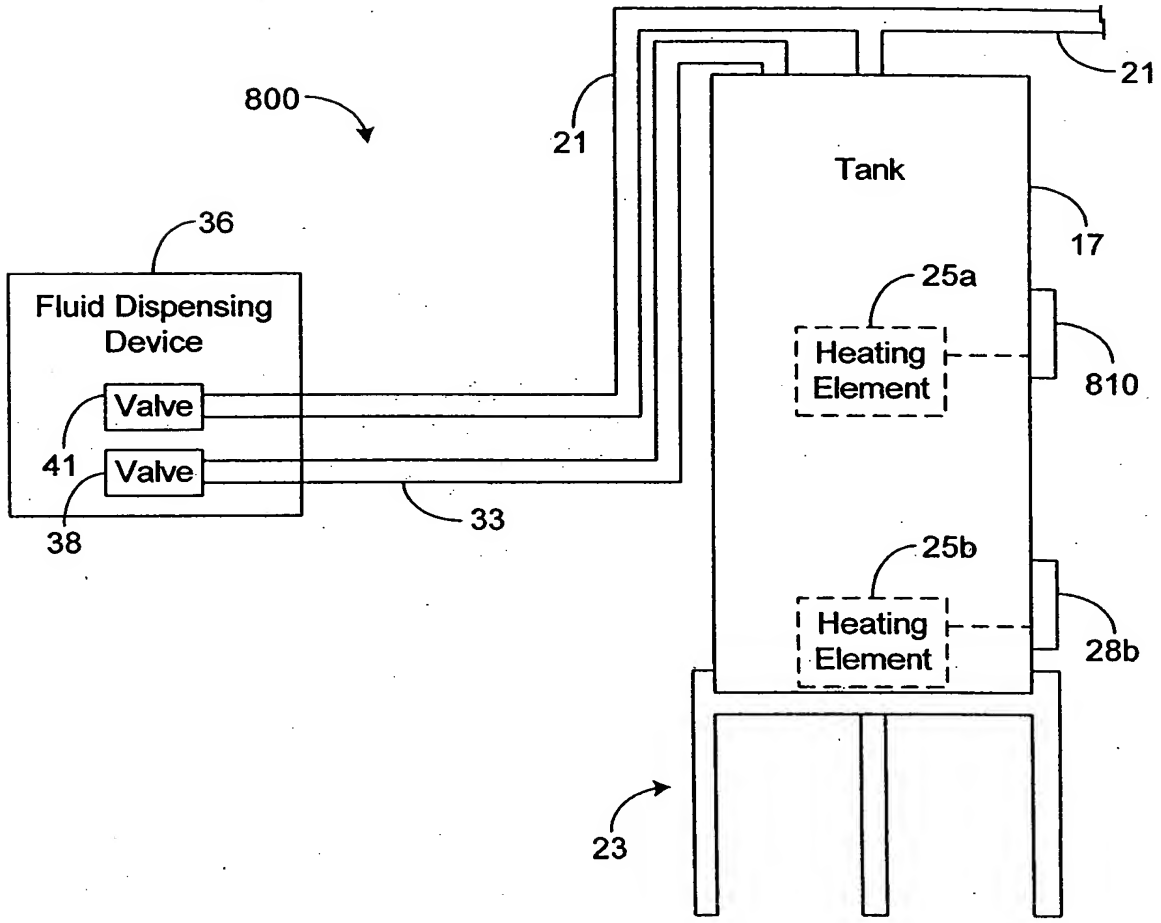
800
21
21
Tank
17
36
Fluid Dispensing Device
25a
Heating Element
810
Valve
41
Valve
38
33
25b
Heating Element
28b
23

FIG. 32

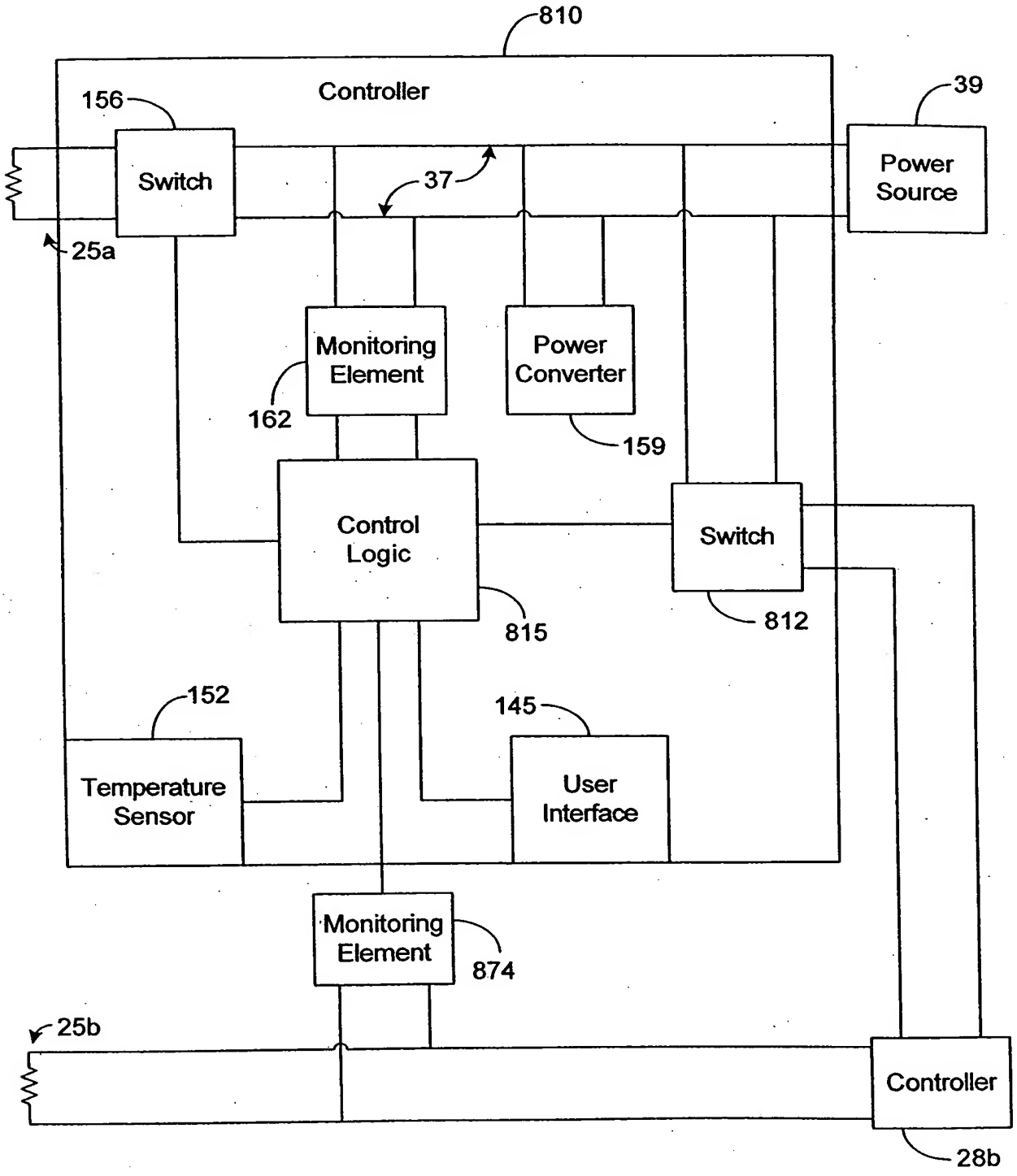
810
Controller
156
Switch
37
39
Power Source
25a
Monitoring Element
162
Power Converter
159
Control Logic
815
Switch
812
152
Temperature Sensor
145
User Interface
Monitoring Element
874
25b
Controller
28b

FIG. 33

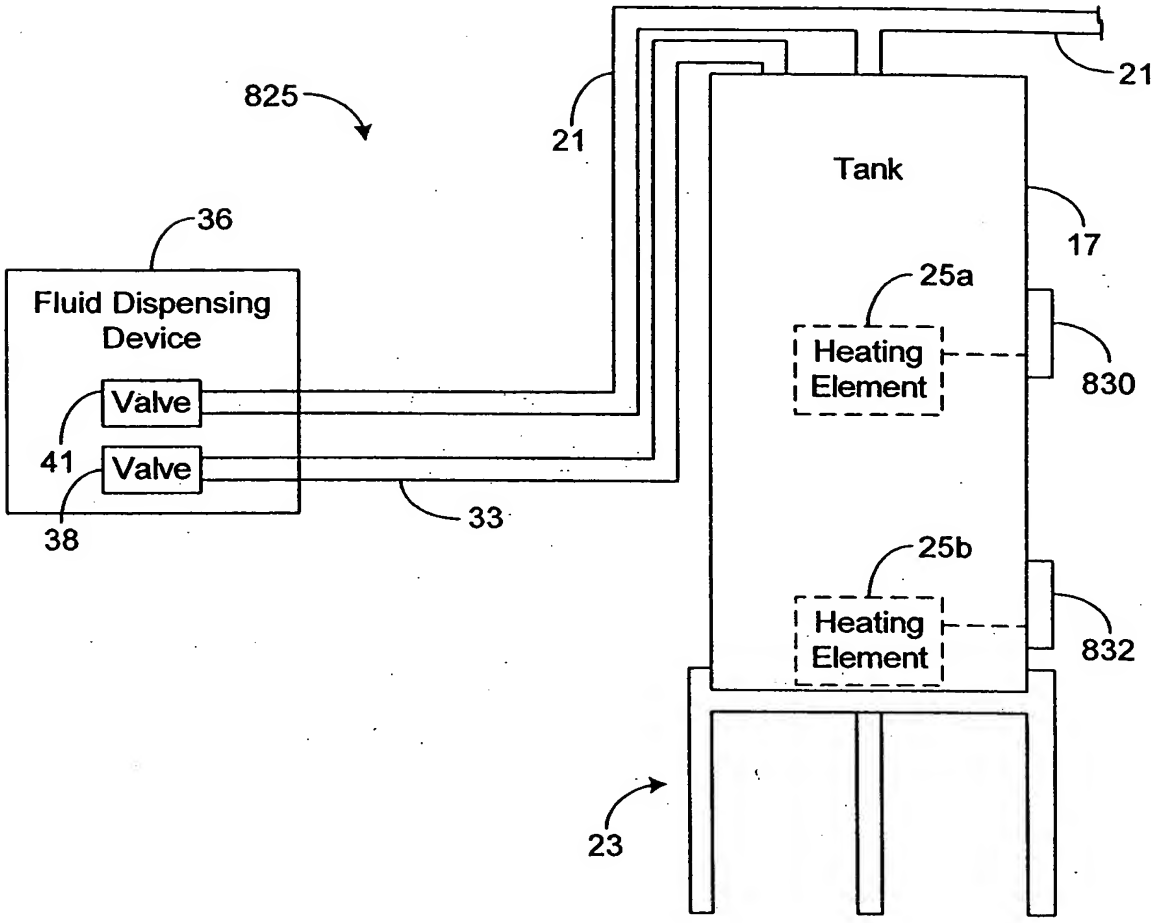
825
21
21
Tank
17
36
Fluid Dispensing Device
25a
Heating Element
830
Valve
41
Valve
38
33
25b
Heating Element
832
23

FIG. 34

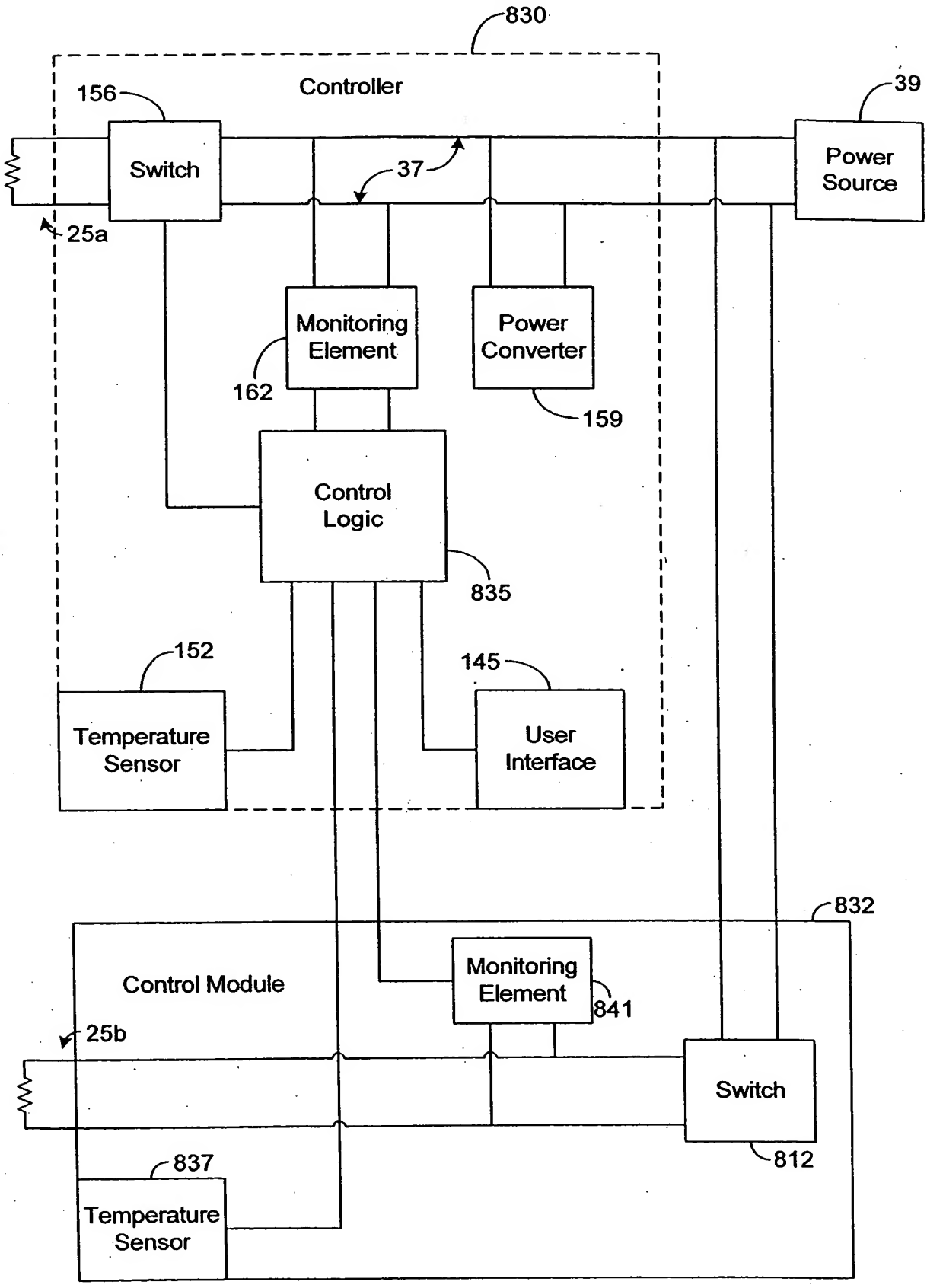
830
Controller
156
Switch
37
39
Power Source
25a
Monitoring Element
162
Power Converter
159
Control Logic
835
152
Temperature Sensor
145
User Interface
832
Control Module
Monitoring Element
841
25b
Switch
812
837
Temperature Sensor

FIG. 35

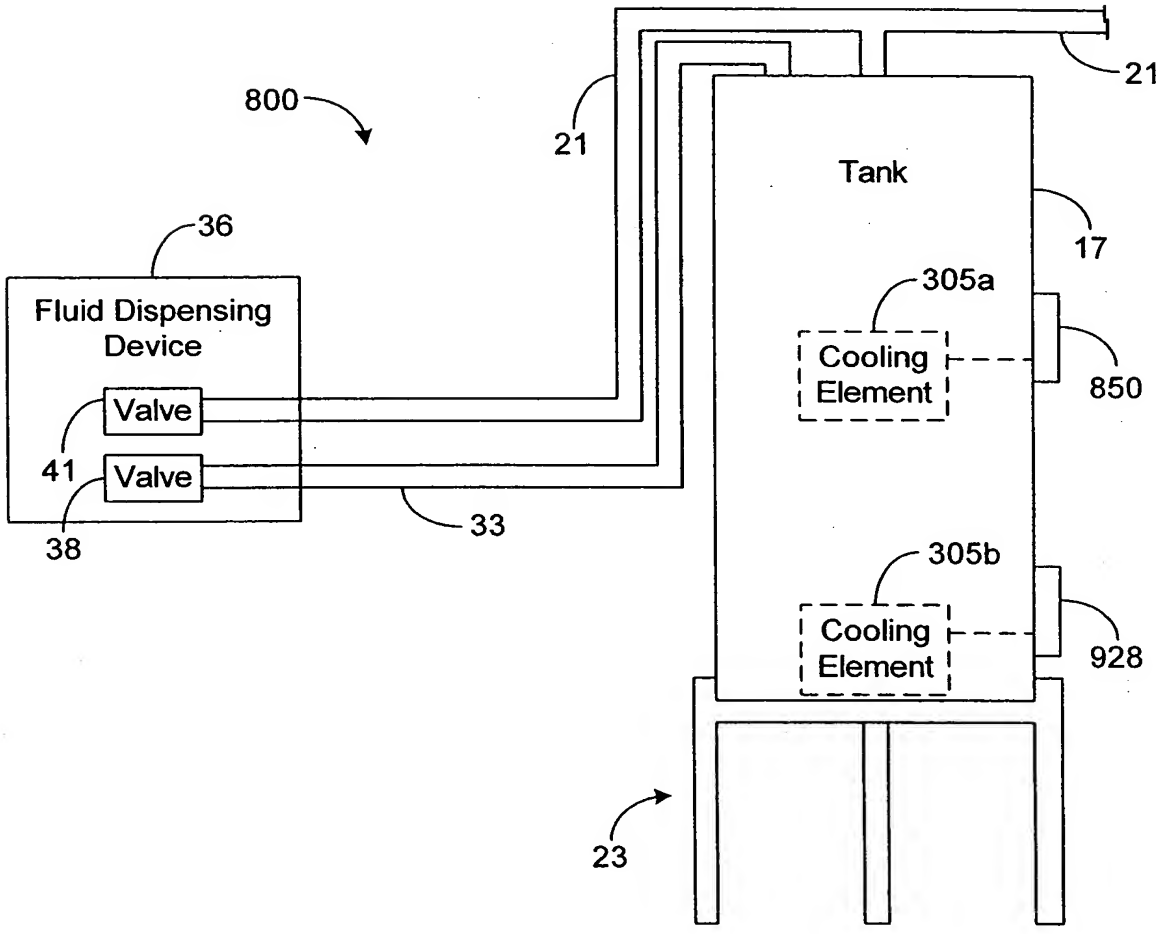
800
21
21
Tank
17
36
Fluid Dispensing Device
305a
Cooling Element
850
Valve
41
Valve
38
33
305b
Cooling Element
928
23

FIG. 36

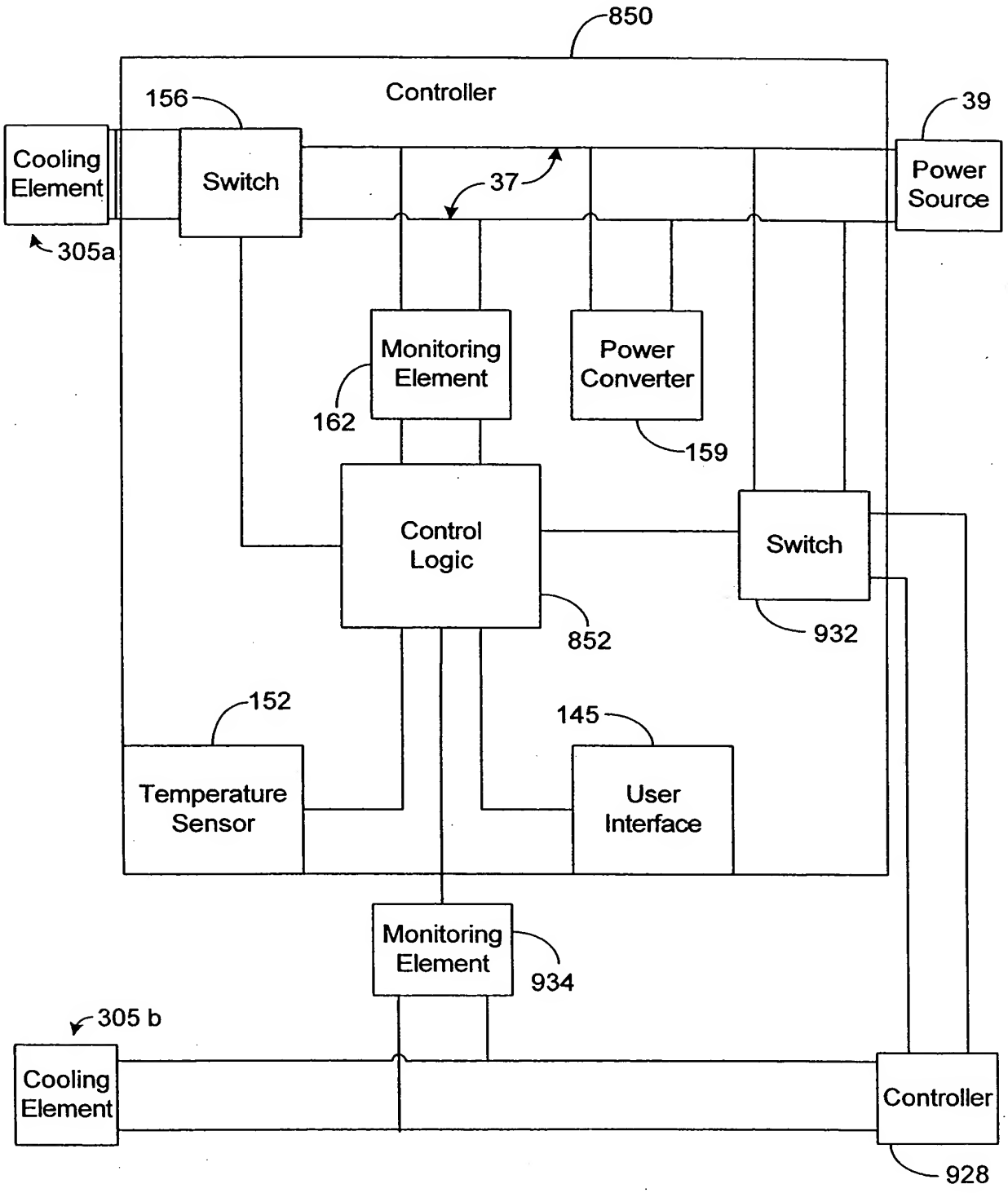
850
Controller
156
39
Cooling Element
Switch
37
Power Source
305a
Monitoring Element
162
Power Converter
159
Control Logic
Switch
852
932
152
145
Temperature Sensor
User Interface
Monitoring Element
934
305 b
Cooling Element
Controller
928

FIG. 37

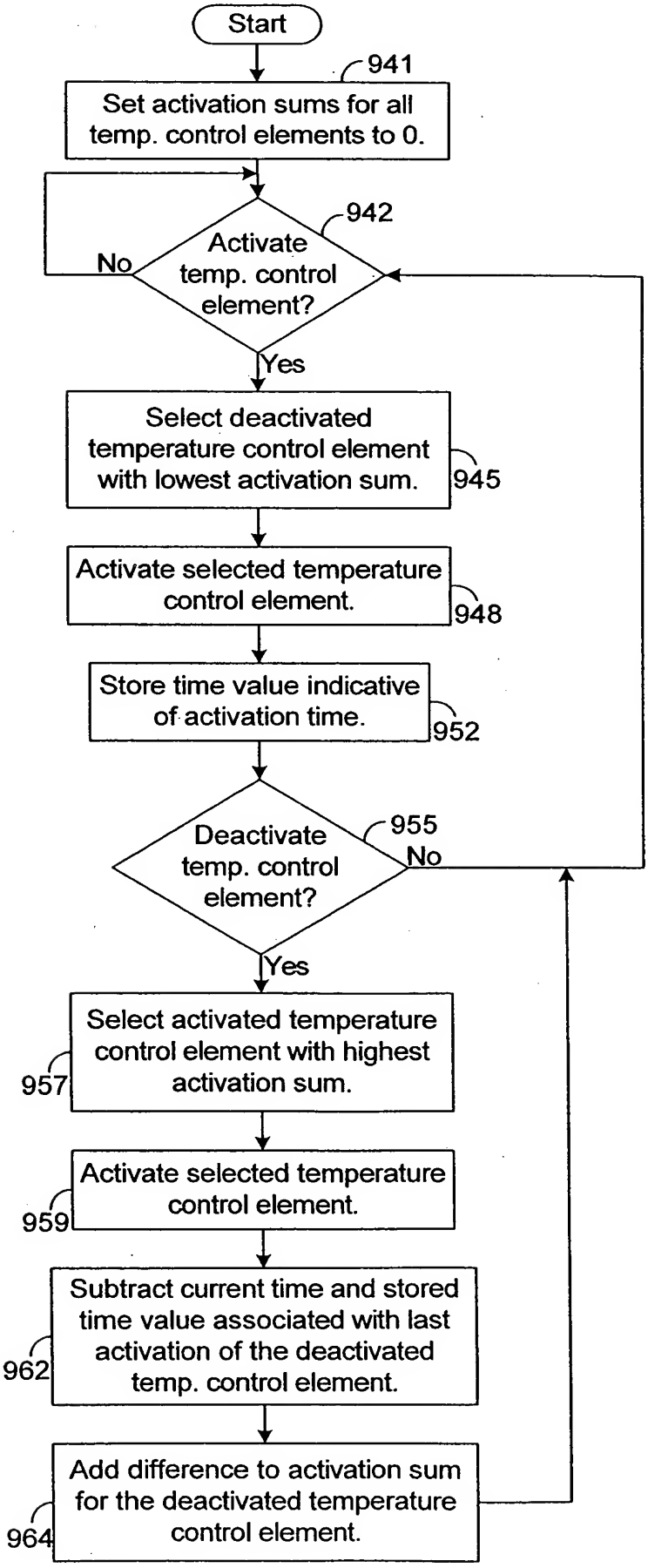
Start
941
Set activation sums for all temp. control elements to 0.
942
Activate temp. control element?
No
Yes
Select deactivated temperature control element with lowest activation sum.
945
Activate selected temperature control element.
948
Store time value indicative of activation time.
952
Deactivate temp. control element?
955
No
Yes
Select activated temperature control element with highest activation sum.
957
Activate selected temperature control element.
959
Subtract current time and stored time value associated with last activation of the deactivated temp. control element.
962
Add difference to activation sum for the deactivated temperature control element.
964

FIG. 38